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Proceedings

of the

Philosophical Society

# of Glasgow.

PROCEEDINGS

OF THE

PHILOSOPHICAL SOCIETY

OF GLASGOW.

VOL. XIII.

1880-81 AND 1881-82.

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ERRATUM.

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PROCEEDINGS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW.

SEVENTY-EIGHTH SESSION.

Opening Address—"Sketch of the Early Years of the Society."

By Andrew Fergus, M.D., President of the Society.

[Read before the Society, November 3rd, 1880.]

1802.—It is but natural that this Society should now and then, as travellers are wont to do, look back on its past history, and review its progress. This is peculiarly appropriate on the important occasion of our meeting for the first time in these new premises, and I therefore purpose to give you an account of our origin, and to take a rapid view of the earlier years of the Society. I shall glean my facts from this old book before me (the book was on the table), it being the Minute Book of the Society from 1802 till 1846, since which latter date the minutes were regularly printed in the *Proceedings*. My first intention was to give merely an outline of the proceedings of the Society, and to recommend that this volume should be submitted to a committee of members well acquainted with the progress of science during the century, and that they should prepare an abstract to be printed and inserted in the *Proceedings*. I have, however, abandoned this idea, and to-night I shall rather attempt to give you a *resumé* of the Society during the first five years of its existence. Should the members wish it, I shall be glad at some future period, when more important matters are not before us, to continue the subject.

In November, seventy-eight years ago, some gentlemen proposed to establish a society, and issued a circular calling together on the 9th of that month all who were interested in scientific and material progress. I shall give their own words:—

"Several gentlemen in this city interested in the prosperity of "the trade and manufactures of their country, and anxious for the "improvement of the Arts and Sciences, thinking it would be of "general advantage were a society established for the discussion "of these subjects agreed to send the following circular letter to "a number of others whom they thought would support and countenance such an institution."

At this meeting on the 9th November a committee was appointed to draw up an outline of the principles of the Society, and on the 16th of the same month it reported as follows:—"Outline "of a plan of the Glasgow Philosophical Society.—1st. Each member "shall upon admission pay three guineas to the funds of the Society. "2nd. The Society shall meet once a week during winter, and once "a fortnight the remaining part of the year, for the purpose of "conversing together on the various improvements which have "taken place, or which may be proposed on the Arts and Sciences; "and where any member may have an opportunity of exhibiting "models of machinery, explaining or reading essays on the same. "3rd. The Society shall have a private room for the purpose of "meeting in, a select library of scientific books, and any occasional "hint which may be considered as an improvement in the Arts "shall be entered into a book which the Society shall keep for "the purpose. A copy of all essays read in and approved by the "Society shall be in the library for the perusal of the members. "P.S.—The Committee appointed at the meeting of the 9th instant "shall proceed to carry the plan into effect as soon as twenty "subscriptions are procured, a preses and court of directors for the "ensuing year shall be chosen by ballot, who shall make out "Regulations for the Society, which may afterwards be amended "as judged necessary. Should twenty subscriptions not be obtained "before the 1st January, 1803, the subscribers are not to be liable "in payment of their subscriptions. Follows the names of the "subscribers—James Monteith, George Birkbeck, James Spreull, "Jas. Sword, jun., David Strong, Patk. Cumin, Joseph Outram, "David Muschet, George Macintosh, Charles Macintosh, John "Monteith, John Lindsay, Wm. Meikleham, James Laird, John "Roberton, William Douglas, Peter Nicholson, Robert Thom,

"James Cullen, Wm. Dunn, Andrew Brocket, James Boaz, John
"Buttery, Robert Kibble, John Smith, Alexr. Drummond, Arthur
"Whyte, John Sharp, James Monach, Kenneth Mathieson, Wm.
"Mitchell, Wm. Reid, John Napier, Robert Hastie, Wm. Broom,
"David Hamilton, James Dunlop, Dreghorn Morrison, Wm.
"Duncan, John Syme, Wm. Stark, Wm. Kelly, David Pattison,
"Henry Houldsworth, Robertson Buchanan, Peter Blaikie, James
"Burns, John Geddes, Malcolm M'Gregor, Wm. Waddell, James
"Haldane, Alex. Galloway, Charles Tennant, Adam Seton, James
"Towers, Wm. Mirrlees, James Sharp, James Younger, jun.,
"Matthew Paterson, John Chadwick."

You will notice that the second name on the list is the well-known Dr. George Birkbeck, afterwards Professor in the Andersonian. There was at that time no philosophical instrument maker in Glasgow, and Dr. Birkbeck found the ordinary mechanics so ignorant of the uses of the various articles which they made for him that he instituted a free course of lectures for "persons engaged in the practical exercise of the mechanical arts." By the fifth lecture the hall was crowded with an attentive and interested audience. These lectures were continued for three sessions. After Dr. Birkbeck's removal to London, he took an active share in founding the first Mechanics' Institution in the kingdom—viz., that of London—of which he was elected President for life. He died in 1841. Preceding him, we have James Monteith, who was, I believe, a well-known medical practitioner in the city, while Patrick Cumin was the then Professor of Oriental Languages in our University. The next name that attracts particular attention is David Muschet, to whom the iron industry in the West of Scotland owes so much. Immediately following Mr. Muschet we find the names of George and Charles Mackintosh, the latter of whom you will recognise as the inventor of the "Mackintosh" or waterproof fabrics now so widely used. We have Mr. John Roberton, ironfounder, who was the first Vice-President, and Mr. Peter Nicholson, who wrote on mathematical subjects, and also published an architectural dictionary. Mr. William Dunn was the well-known machine-maker in John Street, better known, perhaps, as Mr. Dunn of Duntocher. Mr James Boaz was an accountant; he took a warm interest in the society, becoming Secretary in 1804, and to him we are indebted for any interest you may find in my remarks to-night. He acted as secretary for 25 years, and kept the minutes in the most admirable manner. They are written in a very neat, clear hand, and are here and there illustrated by drawings or sketches of some of the articles exhibited at the meetings. The minute book is so precious that I think the Council should get it copied, and then deposited in the safe, not to be removed without their special consent.* The next name I shall notice is that of Mr. Buttery, who, I believe, took an active interest in the Monkland Iron and Steel Company. Then we have Mr. John Napier, father of Mr. David Napier, first of Lancefield, and afterwards of Blackwall, near London. He was also uncle of Robert Napier, the well-known engineer and shipbuilder, and consequently grand-uncle to Mr. James, who took such an interest in the proceedings of this Society, and whose loss we have been so recently called on to deplore. After Mr. John Napier we have Mr. Robert Hastie, one of the Society's most prominent members, and who was its President from 1820 to 1827. His son, Mr. Alex. Hastie, at one time M.P. for the city, succeeded Mr. Boaz as Secretary, and filled that office for many years, first by himself, and afterwards jointly with our late lamented Secretary, Mr. Keddie. Mr. David Hamilton, whose name is also on our list, was an architect of high reputation. He designed the Royal Exchange, Hutchesons' Hospital, and several other public buildings. Mr. Robertson Buchanan was a civil engineer. He wrote on the "Heating of Buildings," "Teeth of Wheels," and other subjects, and was, I believe, the inventor of feathering floats for the paddles of steamers. Again, on our list we have worthy John Geddes, who was to his trade a glass-maker at Verreville, and at the same time the popular colonel of the Lanarkshire local militia. Mr. Haldane was an engraver, and his memory is perpetuated among us by the Haldane Academy of the Fine Arts, which he founded. The name of Charles Tennant will at once recall to you all the founder of the St. Rollox Chemical Works; and James Towers was a Physician and Professor of Midwifery in the University. He was, I believe, the father of the late Mr. Towers-Clark. Those of you who are better acquainted than I with the personal and social history of Glasgow will be able to trace, I have no doubt, the descendants of several more of the original members.

---

* Mr. Boaz was also author of a most interesting volume, which should be read by every one interested in the material progress of Scotland during the last 70 years. The title is, "General Report of Scotland on the Manufactures, Navigation, Commerce, Fisheries, and Banking Establishments of Scotland, drawn up for the consideration of the Board of Agriculture and Internal Improvement."

The first election of office-bearers took place on the 8th December, 1802, and Dr. William Meikleham was elected President. In the following year he was appointed Professor of Natural Philosophy in the University of Glasgow, and held that appointment till 1846, when he was succeeded in the chair by our past distinguished President, Sir William Thomson. By December 29th the Regulations were ready, after having been discussed at several meetings; the entry-money was three guineas, the annual subscription half-a-guinea, and the life membership (which some are inclined to look upon as a modern innovation) was five guineas. The meetings were arranged to be held every Monday, from November to April, and every second week during the other months. By Article 10th it was ordered that if the essays read were approved of, they should be entered into a book kept for the purpose at the expense of the Society. As this, and the two following articles, are new to me, I shall quote them at length:—

"10th. Every essay shall, if the Society or a committee ap-
"pointed by them approve of it, and if the person to whom it
"belongs have no objections, be transcribed at the expense of the
"Society into a book kept for that purpose under the direction of
"the Secretary.

"11th. Two books, one for recording the minutes, and another
"for essays, shall be kept in the room in which the Society meets.
"Besides these, a third book shall always lie in the same room,
"and in which every member shall have the liberty of jotting any
"queries or observations he may think likely to lead to any
"improvement in the Arts, &c.

"12th. These books shall always be accessible to every member
"of the Society, and shall for that purpose lie in the said room,
"out of which they shall never on any pretence be taken, except
"when the Secretary and other managers may judge it proper,
"for the convenience of inserting any transaction of the Society."

I have made every possible inquiry to ascertain if these old books are in existence, but regret to say that hitherto I have been unable to discover any trace of them. The essay book is repeatedly mentioned in after years when papers that have been read are ordered to be inserted into it. When I come to mention the subjects discussed you will see that the loss of this book is a very serious matter, much more so than the loss of the query book, though that is also to be regretted. I daresay it would have given us some amusement to read at this date, from the pages of the latter, the thoughts, ideas, and suggestions which were passing through the minds of the busy men who then formed the membership of this Society.

1803.—I now come to notice some of the subjects discussed at the meetings, and in doing so I may remark that then, as now, the members were most anxious to consider any subject likely to benefit the community at large, or that had any scientific basis or bearing. In January, 1803, Mr. Roberton occupied more nights than one in reading "An Essay on the Advantages to be derived from Heating Cotton Works, Drying-houses, &c., on an Improved Plan," and illustrated the subject by models and drawings.

In February, 1803, the question of water supply to the city was under discussion, and the following month the "Prevention of Smoak." The latter question is much more clamant now, and in Glasgow it has been most shamefully neglected—by the authorities I would say shamelessly so. I hope you will bear with me when I say that the smoke nuisance is a reproach and disgrace to a city like this, so full of mechanical skill and ingenuity. Its effect on the health is injurious, and it is hurtful in another way, inasmuch as we have become so deadened to its offensiveness in an æsthetic point of view that not a single protest is raised against the foul pollution of the beautiful Firth of Clyde during the summer months. I believe that all offensive smoke can be consumed; that steamboats can do so is abundantly proved by seeing them emit only a little almost colourless vapour when they are in harbour. As soon as they leave it, however, all restraint is at an end, and the various summer resorts are polluted by their dense black smoke as they pass them in turn. During calm weather it is really melancholy to see how the beauties of nature are veiled by the clouds of smoke, which, layer upon layer, roll from the successive steamers.

At the end of March James Denholm, the historian of Glasgow, was admitted a member. At the same meeting it was resolved to apply to the Magistrates for a seal of cause in favour of the Society. This matter came up at several meetings, but, as far as I can learn from the minute book, this seal of cause was never granted. We find great variety in the papers read. Mr. Peter Nicholson exhibited two models of roofing, while water-wheels and pumps were brought under notice by Mr. Roberton and Mr. Hastie. On May 11th we find the following minute:—"Mr. John Roberton read to the meeting a "very ingenious and interesting discourse on the construction of a "furnace for burning smoke, in which was fully explained the "principles on which it was founded. The meeting were highly "gratified with this essay, and requested that it might be inserted "in the Society records." I believe Mr. Roberton took out a patent for his invention. On June 8th there is notice that Mr. Roberton, the active Vice-President, had bought when in London a pair of globes for the Society, and in the accounts we find that the price of them was £17, the packing case 36s., and the carriage from London 46s. 6d. I am told that the globes are still in the possession of the Society, although I suppose most of us have never seen them. On November 23rd it was resolved to take a room for the meetings in the Assembly Rooms—the rent is not mentioned.

1804.—On February 29th we find the following entry:—"This "evening Mr. James Boaz produced the telegraph formerly "announced by him, and exhibited the mode of working the same, "much to the satisfaction of the Society, which highly approved "of the invention and of the ingenuity of Mr. Boaz." I believe this telegraph was patented, and perhaps some one may have the opportunity of looking up the patent roll and ascertaining what Mr. Boaz's telegraph was. In June Mr. Roberton read a paper on the "Forces of Moving Bodies, with the measure applicable thereto, and also demonstrated (by models) that time as a measure of these forces is not so necessary as is commonly apprehended." Other members opposed Mr. Roberton's views, and "exhibited models illustrative of their principles." The minute concludes, as many other minutes might, with the quaint assertion, "But, "although much discussion took place upon the subject alluded to, "nothing decisive ever took place." In November Mr. John Geddes was elected President, and Dr. Andrew Ure was admitted a member on the 21st of that month. In the following year he succeeded Dr. Birkbeck as Professor of Chemistry and Natural Philosophy in the Andersonian University, which he held from 1804 to 1830. He took an active part in the establishment of the Observatory here, and was appointed its first astronomer. In 1818 he wrote a paper, which was read before the Royal Society, and published in the Philosophical Transactions, on "New Experimental Researches on some of the leading Doctrines of Caloric."

In 1821 he published his Dictionary of Chemistry, and in the following year his researches on the ultimate analysis of animal and vegetable substances, as well as his translation of Berthollet's work on dyeing. In 1829 he published a System of Geology, in 1830 he removed to London, and a few years afterwards was appointed Analytical Chemist to the Board of Customs. His pen, however, was not idle, as he published the following works: "Philosophy of Manufactures," "The Cotton Manufacture of Great Britain Compared with that of other Countries," and lastly, what was perhaps his most important work, "The Dictionary of Arts, Manufactures, and Mines." At the meeting, Nov. 21st, "Mr. Roberton produced a schedule and drawing of an apparatus for ascertaining the power and other properties of steam, and the Society, having considered the same, requested Mr. Roberton to provide what is needful at their expense." At next meeting a vote of thanks was passed to "Mr. John Roberton, late vice-president, for his unwearied assiduity and exertions not only in founding, but bringing this Society to its present respectability." On December 5th Dr. James Watt was admitted a member, who, besides being a medical practitioner, was also a Baptist minister. He proved a most energetic member of the Society, and on December 26th and January 2nd he read papers on the subject of bringing water into towns. Mr. Boaz followed by showing an apparatus for distilling fresh water from salt. On December 12th Mr. Scott, surgeon-dentist, was admitted. He was somewhat of a butt of Christopher North's or Lockhart's, as the *odontiste* of the Noctes Ambrosianæ—he is there represented as singing Lockhart's song, "Captain Patoun." On December 12th Mr. Boaz exhibited a pump without a piston, which met with universal approbation. On December 24th we find it was agreed that a particular chair be provided for the President, and it was ordered accordingly.

1805.—In January I find an entry, happily rare in our time, viz., the rejection of a candidate for membership. On February 6th Dr. Watt described a new kind of air-pump, which was shown and experimented on at subsequent meetings. The next two evenings were devoted to Phlogiston.

The Philosophical Society considered the subject of gas at an early date. I find the following minute, February 15th, 1805:—"This evening an apparatus was introduced by Mr. George Lumsden which succeeded in forming gas from coals. These having been put into a cast-iron retort, it was placed on the fire. The gas which came over was passed through water, collected in a receiver, and finally forced through a pipe having a small aperture, was set on the fire and produced a very vivid flame. The contents of the retort, which held only an English pint, burnt nearly three-quarters of an hour." The subject occupied the attention of the Society for several subsequent nights, and Dr. Nimmo exhibited a new gasometer on September 16th, and on October 7th read an essay as to the comparative quantity of gas to be obtained "from different kinds of coal, particularly these of Lesmahago, Banton, and Newcastle." In January, 1810, Mr. Gillespie gave an account of his efforts to light his printfield at Anderston with gas.

I find the following minute on October 25th, 1818:—"Coal gas apparatus looked out for the purpose of endeavouring to introduce a cheap method of distilling it for use in private families." The subject of street lamps occupied the attention of the Society for several nights. The fact of the lamps being covered on their inside by condensed water was keenly and frequently discussed. It was argued that this water arose from the condensation of the watery vapour already existing in the air. This idea was disproved by one of the members placing a hot piece of metal in a glass globe, and demonstrating that no water was deposited. It is said that a member of the Police Board induced that body to greatly diminish the size of the lamps, so that they might always be hot, and so not allow the vapour to be condensed. In *this* respect the experiment was quite successful, but the first heavy fall of rain demolished the lamps as effectually as if a lot of mischievous boys had been told off for the purpose. The lighting of the Tron Steeple was repeatedly under discussion in 1821, and finally the plan of reflectors proposed by Messrs. Hart was adopted. About the same time the late Professor Thomas Thomson recommended fewer lamps and larger flames. Next year I find a proposal to purify gas by passing it through a solution of sulphate of iron. In 1823 was a proposal to singe muslin by gas flame. In 1825 we have a notice of a gas engine, and in the following year it was proposed to make gas from cotton seed instead of coal. In 1827 we find mention of a gas governor.

On February 27th the meeting night was changed from Wednesday to Monday. On March 18th we find the following entry: — "This evening being the first meeting held upon "a Monday, Dr. Watt, agreeable to intimation, 6th inst., "read an essay on 'A New Mode of Printing Bank Notes,' "which would be very difficult to imitate, and he produced "several specimens of impressions from natural objects, such "as the longitudinal fibre of mahogany, &c., with all which "the Society was much pleased, not only on account of the "ingenuity of the thought, but of the masterly style of the essay." In April a bookbinder exhibited a new press, and compared it with an old one, asking the Society to give him a certificate of approval. This, however, was declined till the trade should be consulted; but this having been done, it was ultimately resolved that it was a "valuable invention." On January 2nd Mr. Cross promised to bring forward an essay upon "Railrods," but was taken ill and did not read his essay till May 6th. I quote the minute:—"This evening Mr. Cross, according to his promise, "22nd ult., read an essay on 'Railrods,' and exhibited various "drawings and calculations illustrative of the subject, and tending "to show the immense benefit that would result from a general "adoption of this mode of land carriage, which in many cases "would be preferable to that by canals. The Society much "approved of Mr. Cross's project." The question of a diploma was considered at several meetings. It was objected that each diploma would be subject to a stamp duty of 19s. 6d.; but at next meeting it was stated, I suppose on legal authority, that the diploma would not be liable for this tax. The next minute is as follows:—"The drafts of the Diploma were "again fully examined by the members present, when it was "unanimously resolved to adopt the oblong one. That a seal "should be got cut for appending or affixing to the Diploma, but "the consideration of its device was deferred to a future period, "and that in the meantime Mr. Haldane should be employed to "engrave the plate for the Diploma, which, agreeable to the draft, "was to be done all in running hand without any German text, "Roman or Saxon characters. Mr. Thomson read a paper on the "'Principles of Attraction and Vegetation,' wrote and sent him "by a member of the Dublin Philosophical Society. From the "novelty of the opinions contained therein, it was, by Mr. Thomson's consent, ordered to lie on the table for the inspection of "the members. Mr. Wyld mentioned a circumstance which "occurred to him a few days ago, and which he could not account "for. On eating a hen's egg that had been boiled in the shell, he "discovered, in or about the middle of the yoke, a horse's black "hair, about 18 inches long, coiled up spiral-wise. October 7th."

This year the Shannon Club lent the Society a galvanic battery, on which experiments were performed at several meetings. On November 4th Mr. Geddes was re-elected President. Occasionally, if neither essay nor experiments were forthcoming, the Society engaged in conversation, embracing a wide range of subjects. On December 2nd the minute records "the conversation this evening turned principally on soda, vaccine inoculation, galvanism, and manufacturing common sea salt." At next meeting we find a most sensible suggestion, which it is much to be regretted was not carried out—viz., to establish a fully-equipped laboratory in connection with the Society. The subject was brought up repeatedly, and when the Society took a lease of a room in the Surgeons' Hall, St. Enoch Square (the site now forming part of the new hotel and station), at a rent of £16 a-year, it was proposed to build the laboratory behind the hall. Although the subject was discussed at several meetings, I regret to say that I find no trace in the minutes of the suggestion ever having been carried out. About this time the Society had a difficulty from which we are happily free—viz., an inability to get correct accounts of the funds from the Treasurer. This must have happened oftener than once, for some years afterwards the same unpleasant state of matters arose, and the minutes on the subject are most explicit and emphatic.

1806.—January 27th, Dr. Watt read on the composition and decomposition of water. February 10th, Mr. Robertson brought four gun barrels, and showed the tools by which they were rifled. I quote the minutes of February 17th at length :—" This evening, " Mr. Hastie in the chair, a letter was read, dated 1st inst., from " Mr. Robertson Buchanan to Mr. John Roberton, in which he " mentions a plan to be shown by a James Carmichael. Mr. " Roberton described this as being a beneficial way of applying a " high fall of water where the quantity is small. Suppose the " fall 70 feet, let 36 feet of it act through a perpendicular pipe, so " as to press on the lower side of a perpendicular piston. When " the piston has made an *upward* stroke of any given length, cut " off the pressure of the head of water by means of a cock or valve " wrought by hand gear, and allow the water *immediately below* " the piston to pass away therefrom through a vertical waste pipe " of 34 feet. The weight of this column of water will produce a " Torricellian vacuum below the piston, which will consequently " be forced down by the atmosphere, and so give a stroke *downward*. These operations are to be performed alternately. The

" Society was much pleased with this idea, particularly the latter " part of it, which only appears original. In the same letter Mr. " Buchanan expresses a wish that the Society would take into its " consideration how far a saving of expense would accrue from " using springs in carriages for conveying heavy goods."

The pump was remitted to a committee, which reported favourably on it, as follows: — " Sir, — The Glasgow Philosophical " Society having considered the draft of the hydraulic engine which " you sent them, are of opinion that it is very ingenious, particu" larly that part of it which seems to be original, where the water " in your eduction pipe produces a vacuum below the piston; and " in their name I beg to return you thanks for the communication."

On April 28th I find the following minute:—" Dr Watt read " his very ingenious essay on the various uses that could be made " of the condensed water from steam engines, pipes used for heat" ing cotton mills, &c. In this essay the Doctor pointed out that " warm baths might be supplied with hot water, washing-houses, " &c. The aroma of vegetables could be obtained from the steam, " hot beds supplied with caloric from it, with many other purposes " which could be effected in a very economical manner. A vote " of thanks was carried unanimously for this paper."

I find that on May 12th, 1806, a present felt want was supplied. It was then " moved that a footstool be provided for the " President's chair, which was carried, and a card wrote to Mr. " Watt to make one accordingly." Now, when I first had the honour of occupying this chair it was so much more elevated than any I had ever sat in before that, as my feet did not nearly reach the floor, I had some difficulty in keeping my seat. On applying to the librarian he kindly provided me with an old packing box, by the aid of which I have been able to get on with comfort if not with dignity. I humbly submit it to the Furnishing Committee whether the motion alluded to above might not with great propriety be revived in favour of all future Presidents. The Society was very careful of its funds. I see it paid two and a-half guineas to the family of the man who had lighted the fires for the past year, and on June 9th I find a minute which may interest the Furnishing Committee:—" Mr. Watt being present, he was " requested to make for the Society twelve chairs and two arm" chairs, stuff-bottomed, of black birch, the price of the chairs to " be sixteen shillings, those with arms one guinea each." On July 7th Mr. Fleming read a paper on making the Clyde navigable by large vessels. The same subject was continued on the 21st and 28th, also on August 4th. I give the last two minutes:—"Mr. "Fleming read the conclusion of his essay, and Mr. Roberton "delivered his ideas upon the practicability of bringing large vessels "to the Broomielaw. He gave it as his opinion, that by making "the improvements he suggested, and illustrated by different "diagrams, the tide could be made to flow eight feet at Glasgow "higher than at present. A question arose which none of the "members present could answer accurately, namely, the exact "difference of level of the river at Glasgow and Greenock when "at high and low water. This Mr. Wyld promised to inquire "about, and report at next meeting." Aug. 4th.—"Further con-"sideration of the subject of last night was continued thus. Mr. "Wyld reported that he had made inquiry about the height of the "Clyde here and at Greenock, but could not get certain information, "some saying the fall of the river was eight feet, others much "more."

Dr. Ure read on the Doctrines of Chemical Affinities on July 14th, August 25th, and September 3rd. I quote the minute of this last meeting, also the one following:—September 3rd.—"Dr. "Ure furnished the essay upon Chemical Affinities much to the "satisfaction of the Society. Mr. Hastie promised to bring "forward at next meeting some drawings of Mr. Smith's, engineer "at Crownpoint, of machinery by which water could easily be "brought to serve this city from the River Clyde." September 15th.—"The drawings mentioned last minute were exhibited. "They consisted of an elevation and ground plan of two steam "engines, one only of which was to work at a time. The piston-"rod of the engine to be continued so as to form the rod of the "force-pump for raising the water from the river to the reservoir "for supplying the town." Dr. Watt occupied several evenings after this in reading an essay on "Animal Life." On November 10th Mr. George M'Intosh was elected President, and soon after there was a proposal to elect honorary and corresponding members. On December 1st we find rather a warlike proposal made: it was as follows:—"Mr. Peter Fleming suggested an idea of conjoining "two guns or mortars, with a common chamber for gun powder, "and from each gun to throw a ball in a diverging direction, these "balls joined together by means of a chain. The effect would be "great in cutting off whatever obstructed their passage, such as "masts, rigging, &c. A considerable number of remarks were "made in course of conversing on this subject." The next meeting was chiefly taken up with mathematical questions, and the following meeting was occupied in hearing an essay by Dr. Watt on the influence of the "Conscious Principle on the Movements of the Animal Frame." It was resolved that this essay should be inserted in the book kept for that purpose.

Very soon we find the active mind of Dr. Watt making a new proposal. We are told that "Dr. Watt suggested a hint, by way "of query, how far it would be practicable, by enflating small or "large bags with air, that such air, from its elasticity, would be a "good substitute for downs or feathers, and might be useful for "camps, ships, &c.—for camps, as being portable; for vessels, as "they might be used for life-beds in cases of shipwreck."

1807.—About this time smoke consumption occupied the attention of the Society for two nights, and various experiments were detailed. Dr. Watt also exhibited the drawing of a valve to allow air to escape from the upper bends of water pipes. In February the question for consideration was, "Is water by passing through cast-iron pipes injured for practical purposes in the arts of dyeing and bleaching?" After various opinions had been expressed, "the general opinion was that it would be rather dangerous to "establish a work of either of these kinds when the supply of "water cannot be obtained but through pipes of that metal." We have a very long description of a wooden Highland lock, made with the knife, which it is supposed is as old as the time of Julius Cæsar! It appears to have had some of the mechanism of the modern non-pickable locks. At a Council meeting held on March 2nd there are regulations as to honorary and corresponding members, as well as a proposal to admit a limited number of ordinary members free of entry-money.

Next week we find the following minute:—"Mr. Grant suggested, as an expedient to prevent boilers incrusting with the "sediment of impure water, to have two boilers, the one within "the other, the inner boiler to contain the impure water, from "which the steam to be used is raised, being such as the local "situation of the boiler can afford a plentiful supply of. Between the "external surface of the inner and the internal surface of the outer "boilers have pure water, from which when fire is applied in the "usual way steam will arise, but this steam being confined will "necessarily increase in temperature, and give off its caloric in "abundance to the water in the inner boiler, so propagating steam "therefrom as wanted. The space between the two boilers may "be furnished with a heavily-loaded safety-valve to prevent bursting, in case the water in the inner boiler cannot rob of its heat "the steam of high temperature as quickly as the latter receives it "from the fire below. From this construction of double boiler "Mr. Grant thought that no adhesion or deposit of sediment or "calcareous matter from the impure water would take place on "the bottom of the inner boiler, owing to the heat of the steam or "water acting thereon being so much less intense than that of the "bare fire when exposed thereto. Some conversation took place "on this idea. It was generally considered that it would neither "be practicable nor, if so, advantageous." On March 16th Mr. Reid showed a model of a sun-dial, also a spherical dial, "with "meridians cut in it, so that the line between the light and the shade "might be more accurately seen without a penumbra. This globe "to be placed on a pedestal, in such a position that the hour of the "day may be seen not only at Glasgow but at every of the following "places, viz.:—Van Dieman's Land, Japan, Moscow, and Pekin." On April 20th Dr. Watt read his strictures on Mr. Telford's report for bringing water into Glasgow, which was proposed to be printed, either as a pamphlet or in the newspapers. At next meeting Mr. Roberton read on the proposed improvements at the Broomielaw. This was followed by a paper by the Secretary, which I give in the words of the minute:—"Mr. Boaz produced a sketch of the "river Clyde, from the conflux of it and the Kelvin up to near the "Peat Bog. In this sketch be represented a dam thrown across "the channel of the Clyde at the upper end of the village of Long "Govan, with a lock and small canal cut through the very great "bend in the river at that place, where several dry docks could be "built, a causeway to be formed on the top of the dam for carriages "of every kind, where a toll might be exacted—the water of "the river at the fall to be apply^{d} to driving machinery, which "also would yield a considerable revenue. In the night time "and on Sundays, when the water is not used for the machinery, "it will accumulate in the dam, and its surface rising will by "means of floats, he described, raise self-regulating sluices, to let "off the water as it collects, always keeping it at nearly the "same level." These sluices (which he denominated scouring sluices), opening upwards from the bottom will always keep the bed of the river clear of sand and mud. In high freshes the water will glide over the gently inclined plane below the dam down into its natural bed. He proposed that the towing path should be continued on the south side up to Clyde Ironworks or further, as by means of the dam the river would be navigable very far up. A small wharf to be built at Hutchesontown. The Molendinar Burn made navigable for small and fishing craft as far at least as St. Andrew's Square. The Breast between the old and new bridges to be appropriated for vessels of a small draft of water. The bed of the river to be widened at the Broomielaw, and a quay built opposite to the present one, thus superseding the necessity of a wet dock, as by these means the whole river above the dam would be as a wet dock. The most of these and other improvements he mentioned did not, he observed, originate with himself, but were suggested by different gentlemen of this Society and others. 11th May, 1807.—This subject appears to have excited much interest, and I give further extracts from the minutes:—"1st June, 1807.—Mr. Peter Fleming produced a drawing, and "read the report promised at last meeting. He proposed that a "Bar should be thrown across the river at the lower end of the "present quay. To excavate the Green opposite the quay, and "build another on the south side, thus forming a large square basin "with flood-gates of cast iron. He also proposed that, should this "basin not be large enough for the increasing navigation of the "Clyde, to form another wet dock on the north side, all as more "fully explained in the report, which, at the Society's request, he "allows to remain amongst the other essays." Again, on June 8th, we are told that "A general conversation took place on improving "the navigation at the Broomielaw. Dr. Watt proposed that a "digest should be made of the best ideas that have yet occurred "on this subject, and submit it to inspection in some public "place. Mr. Roberton, Mr. Grant, and Mr. P. Fleming gave each "a sketch of a sluice or gate for the river. Mr. Roberton's had a "float, which, being buoyed up by the tide, in rising depressed the "sluice so as to make it descend and lie flat at the bottom of "the water, so allowing vessels to pass over it. When the tide "ebbs the sluice rises, so preserving the same level of water at all "times above the gate. Mr. Grant's was of the same kind, only "that his sluice was to be always perpendicular with the horizon, "and was to rise and fall directly upwards and downwards. Mr. "P. Fleming promised to prepare by next night an estimate of the "bar and of the plan he suggested, as mentioned in minute of 1st "current." Accordingly, on June 15th, "Mr. Fleming gave in "his plan and report, as mentioned last meeting. He proposed "throwing a bar over the Clyde a little above the coal quay cotton "mill, to excavate the Green opposite Clyde Buildings, and down "to the bar, in a straight line from the south end of the new "bridge, to continue the present Broomielaw Quay down to the "bar on the north side, thus forming an oblong square sheet of "water for vessels to lie in, instead of a wet dock, and, being about "400 feet wide and 2200 feet long, will contain many more vessels "than any of the plans proposed by Messrs. Telford, Rennie, or "Baird; to have a lock on each side of the bar for the passage of "vessels up from and down into the river at any time of ebb tide; "the bar to be built two feet lower than ordinary high-water, so "that at full tide the water in the river will flow over the bar "into the dam. He divided these improvements into three distinct "parts—the first is the lengthening the present quay and building "the bar and one lock on the north side; the estimate of this part "was £ . Second, the excavation of the ground at Clyde "Buildings, building a wharf there, and erecting an iron bridge "immediately below the new bridge, for the cartage of goods to "and from the other side; the expense of these he estimated at "£ . Third, to continue the south wharf down to the "bar, and building the south lock, £ —making in all, per "estimate, £25,000. He promised to bring by next night a fair "copy of the report and estimate, which Mr. M'Intosh offered to "introduce to the magistrates. He also proposed having a dry "dock in the garden ground on the north side of the river. This "plan was executed in a very good style, and with it, the report and "estimate, all present were well pleased." On July 6th the subject of friction was under discussion. One gentleman endeavoured to demonstrate that if a smooth body of a cylindrical form was rolled upon a smooth flat surface no friction would ensue, and proposed that this principle should be applied to the gudgeons of a steam engine walking beam, instead of the bushes in present use. On July 7th a map of Glasgow was purchased, which I hope is still in the possession of the Society. The improvement of the river was considered on several occasions, and I shall give a few extracts from the minutes on this subject. On July 13th we find that "Mr. Roberton read the essay promised 6th current, and exhibited "drawings therewith connected. He proposed that at —— yards "below the new bridge at the Broomielaw there should be a pro"jection from the land on each side, for the purpose of contracting "the river to ten yards; at —— yards below this a second similar "contraction, but fifty feet wide; and at —— yards below the "second contraction a third of —— feet wide—making in all three "contractions of the river, at each producing a certain acclivity or "fall of the water, by which means there will be a sufficient depth "at the Broomielaw to prevent vessels ever going aground, and "they may at any time of the tide either pass up or down channel "without hindrance or delay, as in the case of locks." Again, on July 20th, "Mr. Grant read the essay promised last minute, "and exhibited drawings illustrative thereof. The improvement "which was the subject of it was a method of preserving the "water at the Broomielaw always about one height, whatever "might be the time of the tide or ordinary freshes of the river. "This he proposed to effect by a bar built across the channel, the "top of which should be '*low*,' on purpose to prevent too much "damming up of the water, and consequent partial inundations "of the town in cases of heavy swells. But when little water is in "the river the height of this bar should be increased two or more "feet by a series of sluices across the river, moveable on hinges, "and raised up from the outside of the bar to stem the current "and elevate the surface of the enclosed water till it flowed over "their top, each sluice to move on two hinges, the half of each hinge "fixed to the sluice, the other to the top of the bar. These sluices "were to be supported at certain elevations against the current by "means of two levers acting on each sluice, which levers were "acted upon, each by a larger lever. To the end of these large "levers is attached a buoy floating on the water below the bar. "When that water falls low, the buoys falling raise the sluices "first to a *vertical position;* second, when the water gets higher "the buoys rising depress the sluices to a slope corresponding to "the rise of the water; third, when the water gets very high, "the buoys by being raised depress the sluices so much that they "lie in a horizontal position. All these gradations Mr. Grant "illustrated by coloured perspective drawings, diagrams and sec"tions. On the Vice-President putting round the question as to "the members' opinion of the whole, some objections were made by "Mr. P. Fleming and others as to the practicability of the scheme, "and, if practicable, how long these levers, buoys, and sluices would "be able in a complete state of repair to resist the heavy swells to "which the river is subject, accompanied by large bodies of ice "floating down the stream. The scheme, however, was universally "acknowledged to be ingenious, however objectionable or defective "in a practicable point of view."

"On August 10th, Mr. Peter Fleming spoke an extempore "essay upon the means of bringing up from the sea to the Broomie-"law, ships of 300 tons burden and upwards. This, he showed, "could be done by means of making hollow vessels of wood, which "when filled with water were to be attached to the ship's sides "and ends. The water was then to be pumped out of these vessels, "whose buoyancy would then raise up the ship to a height propor-"tioned to the specific levity of the whole. In that state the ship "would partly be suspended or supported as on a flat-bottomed "boat. Mr. Fleming exhibited drawings of this idea, adding that "these floaters or punts could be provided at Greenock and hired "out to the ship so long as would bring her up to the wet dock "proposed at the Broomielaw, and that such hirings might prove "a lucrative branch to a speculator therein. The Society are to "consider of this till next meeting." At next meeting, August 17th, "Conversation took place on Mr. Fleming's proposal men-"tioned in last minute. Instead of pumping the water out of the "floaters, it was suggested to keep them always free of water, and "to force them down near to the ship's bottom by means of screws "and otherwise. However the general opinion was that Mr. "Fleming's original suggestion was most practicable."

When considering the improvement of the river, the question of utilizing the force of the tides was considered. I give you two minutes on this subject:—On July 27th "The Vice-President "delivered an extempore essay upon the different useful purposes "to which the rise and fall of the tides could be applied. He "proposed having a very large float inclosed in a receptacle, in which "was an aperture for the ingress and egress of the tide. At the "flow of the tide this float would be raised with a force commen-"surate to its bulk and levity; and at ebb the float, by the tide "receding from under it, would operate as a weight. These alter-"nate risings and fallings were to act by means of rachets upon a "wheel or wheels connected with the machinery of cotton mills "or other works. The magnitude of this first mover was to make "up for the slowness of its motions, so that it might have in "power what it lost in time. He proposed to apply this principle "to cranes, by making the vessel itself that is to be loaded or "livered to perform the part of the float above mentioned, which "was to act upon machinery for the purpose of working the crane.

"Thus while a vessel lies at a wharf where the tide has access to, "she may without any other power load and unload, or another "vessel at a distance could do the same thing to her by means of "lying shafts connected with the crane. These were the principal "matters the Doctor dwelt upon. It was thought by several "members that the bulk and cost of a float of this kind would be "so enormous for even a one horse-power engine that it could not "be carried into execution with any regard to economy, besides "other objections were urged against it. Next night he proposed "giving a calculation of the bulk and gravity of a float for an "engine of this kind equal to a one horse-power. At this meeting "the unwelcome news reached the Society of the death of George "M'Intosh, Esq., its worthy President." On August 3rd "Dr. "Watt read a calculation promised at last meeting, from which "calculation it appeared that by a rise of tide 11 feet a float of 88 "feet square would be equal to a steam engine cylinder 8½-inch diameter, "6 feet stroke, going 20 per minute. Mr. Hastie produced "another calculation giving the following result:—That on a rise "of tide of 12 feet, a float 59 feet square would be equal to a one "horse-power engine. In this paper Mr. Hastie also demonstrated "that one horse in six hours would raise water 12 feet sufficient "to fill a cistern 1760 feet area, 12 feet deep."

I.—*Suggestions as to Amendment of various Franchises, and Improvement in Mode of Levying and Collecting Rates and Assessments in Scotland.* By WILLIAM CAMPBELL, Assessor, Glasgow.

[Read December 1st, 1880.]

IT having been suggested to me that, as I happened to be acquainted with the various franchises, I might give a short sketch of the nature and effect of these franchises, accompanied with such suggestions as might occur to me—especially with reference to my own department as Assessor, and to the amendment of the existing franchises and improvement in the method of levying and collecting the various rates and assessments—I have, therefore, noted a few matters connected with the subject, which I shall endeavour to detail to you in as few words as possible.

It may be desirable at the outset to give a short statement of rental, population, and dwelling-houses, as these matters have a considerable bearing upon the franchise question:—

RENTAL OF GLASGOW.

There is no proper record of the rental of Glasgow prior to 1855. But from old records information can be gleaned which shows in a marked manner how small it must have been in 1712 compared with what it is now. In that year the total rental of Spreull's Land, then the most valuable in the west end of the Trongate, was £56 13s. 4d. In this land Ladies Glencairn, Auchinbrock, and Craignish had their town houses, the rents of which were £9, £6 13s. 4d., and £5 10s. respectively.

At this period there were only 202 shops in Glasgow, the highest rent being £5 and the lowest 12s. Just imagine for a moment what kind of a shop could now be had in Glasgow for 12s. The commonest coal-ree would bring a rent at the present time of four times that sum. The average rental of shops in the Trongate now is £174. Although there has been no record of the rental of Glasgow until a recent period, a list has been found of persons assessed in 1816 according to their means, from which it appears that the gross value of property of persons owning £300 and upwards amounted to £7,016,900. If we take the rental of Glasgow for 1879, which amounts to £3,432,000, at sixteen years' purchase, we have heritable property worth £54,912,000, exclusive altogether of personal property, which must amount to a very large sum. This shows the rapid strides Glasgow has made in such a very short period. The first authentic record of rental we have in Glasgow is the Valuation Roll made up in 1855, under the provisions of the Lands Valuation Act for Scotland passed in 1854. The annual rental for the area of the present municipality was, in 1855, £1,380,892. The annual rental for the same area for the year 1879, as already stated, was, in round numbers, £3,432,000, showing an increase between the years 1855 and 1879 of about 145 per cent.

The present suburbs of Glasgow may be said to be as much Glasgow as the area of the present municipality was in 1855, because nearly all the suburbs have grown up from the overflow of Glasgow since then, her boundaries being a fixed line under the Reform Act and the Municipal Act of 1846, with two very trifling extensions between the years 1872 and 1878. Were the rental, therefore, of these suburbs added to the increase in Glasgow—which it ought to be, in order to show the true and real progress of Glasgow—the increase would be upwards of 200 per cent. since 1855. In connection with this subject it may not be out of place to remark that Glasgow, like most great cities, has grown or extended more in a southerly and westerly direction than in a northerly and easterly direction. This is evidenced by the fact of the creation of the eight police burghs of Hillhead, Partick, Govan, Kinning Park, Pollokshields, East Pollokshields, Crosshill, and Govanhill, which form a cordon around Glasgow in a southerly and westerly direction, and so prevent Glasgow growing a step in these directions.

POPULATION.

Although there have been no records of the rental of Glasgow from an early period, there are authentic records extant as to its population.

The population of the city has gradually and rapidly increased since the union with England in 1707. The first authentic enumeration of the people that was taken in the city was in the year 1610. At that period the inhabitants amounted to 7644; in 1614 the number had increased to 8000; in 1660, at the restoration of Charles II., to 14,678; in 1688, at the Revolution, the number had declined to 11,948; the religious troubles, or what was then called the persecution, are given as, and undoubtedly were, the cause of the decline. In 1708, after the union with England, the number had increased to 12,766. In 1712 the inhabitants were numbered, by order of the Convention of Royal Burghs, and the number then sworn to was 13,832. In 1740 the number had increased to 17,043. In 1743, again, it had increased to 18,366. In 1757 the then suburbs, which are now within the boundaries of Glasgow, were included in the aggregate, and the number then was 23,546. But I need not trouble you too much with details for such short periods. In 1801 the population was 83,769. In 1811, at the census, the number was 100,749. In 1831 the population of the city and suburbs—the then suburbs, as already stated, now forming part of the city—was 202,426. At the census in 1871 the population of the present city was 491,964. It is estimated that the population of the city is now about 550,000. If to this the population of the suburbs were added, which, as before remarked, is really the overflow of Glasgow, we would have a population of upwards of 700,000, proving in the clearest manner the rapid rate Glasgow has increased within a recent period.

DWELLING-HOUSES.

The number of dwelling-houses in Glasgow in the year 1879 was 119,073. The number occupied was 107,200.

Of this latter number there are rented under		
£10, - - - -	73,026	
and rented at and above £10, -	34,174	
	———	107,200

This will show, at a glance, that the inhabitants of Glasgow are composed principally of the working-classes. From the great railway facilities provided by the railway companies to and from Glasgow the better-off and well-to-do merchants, manufacturers, traders, and others now reside beyond the city bounds; and year by year this will go on increasing as new suburbs come into existence and such facilities are continued and extended.

FRANCHISES—BURGH AND LOCAL.

The present franchises for parliamentary and municipal purposes are conferred as follows, viz.:—

1. On persons entitled to vote in the election of members to serve in Parliament.
2. On persons entitled to vote in the election of Town Councillors.

These franchises are provided for under the Reform Acts of 1832, 1833, and 1868.

The register of voters made up for parliamentary purposes is declared by the Registration of Voters' Act, 1856, and subsequent Acts, to be also the register for the election of town councillors, so that there is only one register in such burghs for parliamentary and municipal purposes where the boundaries are co-extensive; but where the boundaries are not co-extensive a separate list of voters for the portion of the municipality beyond the parliamentary burgh is made up under special statutes—the parliamentary register answering for the municipality within the parliamentary burgh.

Prior to 1856, in order to make up the register of voters, it was necessary for each person entitled to be enrolled to lodge with the Town-Clerk a claim, filled up and signed by him, and for which he paid a fee. These claims had to be printed and published by the Town-Clerk, and hung up on the church doors. The claims were subsequently adjudicated upon by the Sheriff, in Courts held for the purpose, who admitted or rejected the claims, according to the evidence adduced, each claimant or his agent being obliged to attend to his claim before the Registration Courts; and the Registers of Voters were thereafter made up and completed from the admitted claims. This was a very cumbrous way of making up the registers, and entailed upon the persons entitled to enrolment a great deal of unnecessary expense and annoyance. So much was this found to be the case that the Burgh Voters' Act was passed in 1856, under which assessors were authorised to be appointed for making up, printing, and publishing annually a list of persons entitled to be enrolled as voters under the Registration Acts, the expenses to be borne by an assessment provided by the Act to be levied upon the owners and occupiers of heritages in the burgh.

The Valuation Act for Scotland, passed in 1854, provides that assessors shall be appointed by the commissioners of supply in each of the counties, and by the magistrates in each of the burghs, to make up annually a valuation roll for each of the counties and burghs respectively, showing the yearly rent or value for the time of the whole lands and heritages within such county or burgh respectively, specifying in each case the nature of the lands and heritages, and the names and designations of the proprietors or reputed proprietors, and where there are tenants and occupiers, of the tenants and occupiers respectively. The assessor, under the Burgh Voters' Act of 1856, must be the same person as is appointed assessor under the Valuation Act; and by section 17 of the Burgh Voters' Act it is provided that the valuation roll so to be made up shall be received and taken, with reference to the preparation of the register of voters, as *primâ facie* proof that the gross yearly rent or value of any subjects specified in such valuation roll is and has been for the year from the 15th May in each year of the amount set forth for the time in such valuation roll, and also as *prima facie* proof that the persons therein set forth as proprietors, tenants, and occupants, respectively, have, for the period to which such valuation applies, been such proprietors, tenants, and occupants, respectively, as therein stated. And it is from this valuation roll, and from the annual survey made by him of all separate houses and premises, that the assessor, under the Burgh Voters' Act, 1856, obtains the information necessary to enable him to prepare the register of burgh voters annually, as provided for by that Act and the Reform Act of 1868. By the Burgh Voters' Act provision is made for persons who, from any cause, may have been omitted from the register made up by the assessor, lodging claims, from the 15th to the 21st September, with the assessor, to be considered and disposed of by the Sheriff. These claims have always been comparatively few in number when the number of voters on the register is taken into account.

The franchises in parliamentary and municipal or royal burghs, in short language, consist as follows:—

1. Owners of property within the parliamentary and municipal boundaries, respectively, of the annual value of £10 and upwards. These owners must have resided within the boundaries, or within seven statute miles thereof, for six months prior to 31st July each year.

2. Occupiers of premises, whether dwelling-houses, shops, or warehouses, &c., within the same boundaries, of the annual value of £10 and upwards, who have, for twelve calendar months prior to 31st July, occupied the same or similar premises, and, in the cases of business premises, have resided for six calendar months prior to 31st July within these boundaries or within seven statute miles thereof; and partners of firms, whose residential qualifications are the same as sole occupants, and whose respective shares or interests in the premises are of the annual value of £10 and upwards.

It is provided that these owners and occupiers shall have paid all assessed taxes, and shall have not been in receipt of parochial relief within twelve calendar months.

3. Occupiers of dwelling-houses *under* £10 of annual value who for twelve calendar months preceding 31st July have inhabited or resided in the same or similar dwelling-houses within the foresaid boundaries, and who have paid, on or before 20th June each year, all poor rates due by them, and who have not been exempted from the payment of poor rates, and who have not received parochial relief during the year prior to 31st July.

4. Lodgers who have for the twelve calendar months preceding 31st July occupied lodgings within the said boundaries of a clear annual value, if let unfurnished and without attendance, of £10 and upwards.

The number of parliamentary electors on the register for Glasgow for the year 1879-80 was...	57,920
and for the portion of the municipal burgh beyond the parliamentary burgh the number was	2,497
making the total municipal constituency of Glasgow ...	60,417

As already stated, the number of occupied houses in Glasgow in 1879 was 107,200; and it may appear at first sight somewhat strange that out of that number only 60,417 persons' names are entered in the municipal register of voters. The difference is accounted for as follows:—(1) To be a voter as a householder the occupant must have been in possession for twelve months prior to 31st July each year; but a considerable number of the occupants have only been in possession from the Whitsunday immediately preceding, and so have not had the twelve months' residential qualification; (2) a considerable number of persons occupying houses are females, who are not voters; and (3) last year there were in Glasgow upwards of 28,000 *male* occupiers of houses rented under £10, who for the previous year failed to pay, or were exempted from payment of, their poor rates. These three causes explain the discrepancy between the great number of occupied houses and the much smaller number of voters.

There is another kind of franchise in burghs, viz., the electors entitled to vote in the election of managers of the poor in each parish. There are three such parishes in Glasgow. This franchise is conferred by the Poor Law Act of 1845 on owners and occupiers of lands and heritages in each of the parishes who have paid their poor rates for the year, each owner or occupier being entitled to a certain number of votes, according to the extent of their rentals respectively, the highest number of votes allowed to be given being limited to six in all. This franchise extends to females as well as males.

There is also another franchise in burghs under the Scotch Education Act of 1872. These electors consist of all *persons* whose names are entered in the latest completed Valuation Roll as owners or occupiers of lands and heritages of the annual value of £4 and upwards, situated within the school district for which the School Board is to be elected. This franchise also extends to females, as in the case of the Poor Law franchise.

A variety of other bodies, as well as individual persons, are entered in the Valuation Roll as owners and occupiers; but the firms, companies, &c., entered in the Valuation Roll are not School Board electors, inasmuch as they are not *persons*. It has to be observed that this franchise is not limited to such persons as pay rates, as in the cases of the other franchises. The result of this has been that the members of the School Board have been elected by a very great number of persons who have not paid rates at all—the average number of *male* occupiers of houses in Glasgow under £10 of rent since the year 1868 who have not paid rates being about 25,000 a year, while the firms, companies, &c., which are very numerous, have no voice in the elections, and yet they one and all pay their rates. In the case of twelve firms, which I have selected as examples of the injustice done to such ratepayers, I find these twelve firms have a gross rental of £34,884 a year, which is equal to the average rental of 4983 houses under £10, many of the occupiers of which do not pay rates at all; yet the occupiers of the 4983 houses are one and all School Board electors. In short, the School Board electors are principally male and female occupiers who do not pay rates, while the *bona fide* ratepayers are excluded from a privilege which payment of their rates ought to give them.

FRANCHISES—COUNTY AND LOCAL THEREIN.

These franchises were conferred by the Reform Acts of 1832 and 1868 upon nearly the same class of electors, with certain additions and distinctions, provided for under the Acts—the qualifying rental for owners being £5, and for occupiers of £50 and upwards, whether such last-mentioned occupiers pay rates or not; and for occupiers of £14 and under £50 who have paid, on or before 20th June, all poor rates due by them, and who have not been exempted from payment of rates, and have not received parochial relief. This register of electors was formerly made up by claims lodged in the same way as for the burgh voters' register, and this mode of making up the register of county electors produced the like expense and annoyance as the making up of the burgh register did. In consequence of this the County Voters' Act of 1861 was passed, which provided for the making up, by specially appointed assessors, of registers of voters for counties in a somewhat similar manner to that already explained for making up the register of voters for the burghs.

There are also certain local franchises in counties conferred on the *male* ratepayers in police burghs (outside parliamentary and royal burghs) occupying heritages in these police burghs of the annual value of £4 and upwards, as provided for under the General Police Acts 1862 and 1868, the commissioners of supply having jurisdiction and assessment powers therein as well as over the remainder of the county. No owner, unless he be also an occupier, can vote in the election of the commissioners in these police burghs.

There is likewise a franchise in the county for the election of the parochial boards or managers of the poor, and also for the school boards in the several parishes within the county, outside parliamentary and royal burghs. These franchises are of a somewhat similar character to the parochial and school board franchises in parliamentary and royal burghs which have already been referred to.

Suggestions for Amendment and Assimilation of Franchises in Parliamentary Burghs and in Counties in Scotland.

I.—PARLIAMENTARY BURGHS IN SCOTLAND.

From the practical experience I have gained, I have come to be of opinion that the only sound and fair representation which ought to prevail for every purpose is that based upon payment of rates. Representation and taxation ought to go together for franchises of every kind. I am further of opinion that in parliamentary and royal burghs there should only be one register of voters for parliamentary, municipal, poor law, and school board elections, and that that register should be declared to be the register of electors made up under the provisions of the Burgh Voters' Act of 1856, and the Reform Act, 1868, already referred to; and that the electors should be:—

(1). Owners for six months of lands and heritages—having the meaning attached to that expression in the Valuation of Lands Act,—whether joint or sole, of £5 of rental and upwards, and who have resided or carried on business in the burgh for twelve months prior to 31st July yearly.

(2). Occupiers of lands and heritages, having the meaning attached to that expression in the Valuation Act, whether joint or sole, of any rental, and who have occupied such heritages in the burgh for twelve months prior to 31st July yearly.

(3). Females who are unmarried, widows, and married women living separate from their husbands and whose earnings are protected by law, and who are owners or occupiers as under Nos. 1 and 2 above, should also be electors, seeing that in poor law and school board elections females are electors.

I would also suggest (1) that the seven mile limit of residence from burghs, of persons being owners or occupiers, whether joint or sole, of premises in the burgh other than houses, should be abolished, substituting for this residential restriction a provision that such persons, if they do not reside in the burgh, should occupy premises and carry on a permanent business or trade in the burgh either as an individual or as a partner of a firm or trading company. My reason for this is that great inequalities, and I may say injustice, has arisen under the operation of this seven mile residential clause. When the Act of 1832 was passed very few people resided beyond the burgh; but now, with the great facilities for travelling, many people carrying on permanent and fixed businesses in large towns (and who have a greater interest in such towns than the floating population who occupy the smaller class of houses) reside at a greater distance from such towns. And I am of opinion that the restriction to the carrying on of business or trade in the burgh is all that is required to give persons residing beyond it a fixed connection and interest in the burgh, as proposed under heading No. 1.

Just to give an example of the inequalities that have arisen in connection with the seven mile clause: Several gentlemen who reside in a certain part of the town of Hamilton, which part is within the seven mile limit, and who carry on business in Glasgow, are on the register of voters for Glasgow; but several other gentlemen who reside in the town of Hamilton, but immediately *beyond* the seven mile limit, and who also carry on business in Glasgow, are *excluded* from this register—yet these two sets of gentlemen have precisely the same interest in the burgh, the only difference being an imaginary boundary line.

(2). That the assessor under the Registration of Voters' Act should have power to enrol lodgers in the same way as he does partners of firms who are joint owners or joint occupiers, on being satisfied that such lodgers have the requisite £10 rental qualification.

(3). That no person should be enrolled more than *once* as an elector in the register of voters for the same burgh.

(4). That the existing clause in reference to payment of poor rates in the Act of 1868 should be made applicable to all the classes of electors under Nos. 1, 2, 3, and 4 before-mentioned. Were this done a uniform, fair, and equitable franchise would be obtained. There is no reason, in my opinion, why a person at present owning or occupying premises of £10 rental and upwards should have the privilege of being an elector when he has not paid his rates, any more than the person occupying premises under £10 of rental. Both in fairness ought to pay.

(5). It further appears to me that provision should be made for there being only one parochial board, or one set of managers of the poor in parliamentary and royal burghs, as in the case of school boards,—which latter boards are appointed for the whole burgh, and have to exercise and carry out equal, if not greater duties than those falling to be discharged by parochial boards. This would secure uniformity of action in each burgh—all would be equally rated for the same purposes—the expense of a separate staff of officers for three boards would be saved, as in Glasgow, for instance—separate offices would not be required, and a deal of unnecessary expenditure would be saved, to be applied to the relief of the poor, whereby the taxation for that purpose would be reduced. The police, the sanitary staff, cleansing and lighting of the city, fire brigade, &c., &c.—more important duties than poor-law management—are all placed by statute under the control of one body for the whole burgh. It may be thought by some people that the area of a burgh such as Glasgow or Edinburgh is too large for one set of poor-law managers. The answer to this is, that it has not been found so for the equally, if not more, important duties I have referred to.

But, assuming that the objection had a semblance of reality, it can easily be obviated by the fixing of districts, appointing district committees with certain powers, and appointing a sub or district inspector, or inspectors—such committee to report on special matters to the central board, and the sub-inspector to the principal inspector.

(6). Certain inequalities exist in the present parliamentary and municipal franchise. For instance, a person changing the nature of his qualification as a voter is disfranchised for twelve months. Such as—

1. A lodger ceasing to occupy lodgings and becoming a tenant and occupant.
2. A tenant and occupant becoming a lodger.
3. An individual tenant and occupant becoming a joint-tenant and occupant.
4. A joint-tenant and occupant becoming an individual tenant and occupant.
5. An individual owner becoming a joint-owner.
6. A joint-owner becoming an individual owner.
7. An owner becoming a tenant.
8. A tenant becoming an owner.

These separate electors have all the same privileges as voters when once enrolled; and if any person has been so enrolled in one capacity, it seems but fair that, if the voter has been in the continuous ownership or occupancy in the one capacity or the other, that he should be entitled to be enrolled as a voter, and that the changing of the character from one capacity to another should not act as a disqualification at all. Provision should be made to do away with such inequalities.

II.—COUNTIES IN SCOTLAND.

It appears to me that no good reason can be adduced against the franchise for all purposes being made applicable to counties in the same way as to burghs. By the overflow of cities into counties, and with the advance made by the inhabitants of counties through the spread of education and otherwise, these inhabitants are quite as well qualified to be electors as the residents in parliamentary burghs. For instance, the police burghs of Govanhill, Govan, Partick, Hillhead, and Maryhill in the county of Lanark, and the police burghs of Kinning Park, Pollokshields, Pollokshields East, and Crosshill, in the county of Renfrew, contain the same class of people as reside in Glasgow; but these people, unless they occupy a £14 house, are disfranchised, merely because they may happen to reside on the other side of a boundary line, which in numerous instances is merely an imaginary one. In some cases, again, one part of a common tenement is in the parliamentary burgh and the other part is in the county. That being so, my opinion is that the parliamentary franchise for counties should be precisely the same as has been suggested for parliamentary burghs, and that the register so made up for counties should be declared to be also the register for the election of commissioners in police burghs, the managers of the poor, and the members of school boards within the county—the register to be made up in such a way as to distinguish the parishes and the police areas from one another, for the purposes of voting in each separate area.

Suggestions as to Uniformity and Simplification of Rating.

I.—PARLIAMENTARY BURGHS IN SCOTLAND.

At present the magistrates and town councils in parliamentary burghs are empowered to assess, levy, and collect the police and the various other local rates requiring to be levied by them under numerous statutes, within the entire burgh, all of which are included in one assessment roll, and are assessed and notified in one notice or demand-note. There are also the parochial boards in the burghs, each of whom make up, assess, levy, and collect, each by separate staffs, the poor rate, and along with it the school rate. A great deal of money, which is unnecessarily expended for these separate staffs, roll books, and assessment notices, could be saved were all the rates paid at one place, and all the trouble of going to different places to pay be avoided, if the power of assessing, levying, and collecting all assessments in burghs in one notice or demand-note were vested in the magistrates and town council—the members of which are the true representatives of the ratepayers. Provision would, however, require to be made for the school board, and the suggested one parochial board for the burgh, calling on the magistrates and council by requisition annually to assess, levy, and collect the amount required by such boards, by an assessment to be included in the suggested one assessment notice or demand-note—such assessment to be paid over to such school and parochial boards when collected. Further provision would fall to be made to the effect that all assessments should be levied on one uniform principle, and according to the rental or annual value as appearing in the valuation roll, without any deduction whatever.

II.—COUNTIES IN SCOTLAND.

Seeing that the commissioners of supply of counties have jurisdiction in the entire counties, excepting always parliamentary and royal burghs, and are vested with the like powers of assessment in such counties, including police burghs, as the magistrates and town councils are vested with in parliamentary burghs, it appears to me that no distinction should be made as to the commissioners of supply in counties, or such other body as the legislature may appoint, exercising precisely the same powers and in the same way in counties as has been suggested that the magistrates and town council should be vested with in parliamentary burghs, and that the commissioners of supply or such other one body should be so vested accordingly—the reasons existing for the suggested change in counties being the same as in burghs. Were this done there would be only two boards having charge of assessing in a county, namely—the commissioners of supply, or such other one body in the county, as distinguished from the parliamentary and royal burghs therein, and the town council in the parliamentary and royal burghs, which although in the counties are separate and distinct from the counties for all purposes.

Were these suggestions carried out in a measure to be passed by the legislature, I am satisfied, from the careful consideration I have given to the questions at issue, that a great and satisfactory improvement would be made, and a beneficial change effected in and for the interests of the community at large.

II.—*On certain Seeming Relations between the Three Larger Planets crossing in Front of the Sun's March, and the Phenomena of Sun-spots and Terrestrial Magnetism, &c.* By HENRY MUIRHEAD, M.D., Cambuslang, Vice-President of the Society.

[Read December 1st, 1880.]

IN 1875 I brought my second paper* before this Society. It bore the formidable title, "On the Genesis of Atoms, Worlds, and Sun-spots." In it, amongst other matters, I called attention to the remarkable synchronism observable between the maxima and minima of sun-spots on the one hand, and certain relative positions of Jupiter in the solar system on the other. I also brought forward the hypothesis that probably sun-spots are occasioned by large masses of meteoric matter impinging against the sun's gaseous envelopes, becoming imbedded therein, sailing round the sun more or less synchronously with his rotation, or at least with the rotation of his envelopes; and while so sailing causing those less lustrous appearances called sun-spots, in consequence of the coolness induced through the rarefaction of the meteoric masses until they are finally sublimated.

It may be objected to this hypothesis that such bodies impinging against the sun's atmosphere ought rather to occasion a brightening of the solar radiance, just as the so-called star-shower meteoric displays light up our atmosphere. Well, I imagine it to be highly probable that they do so act in coming frictionally in contact with the sun's surroundings; and, if the meteoric masses or swarms go somewhat directly and deeply into them, are likely also the occasioning causes of those jets of fiery liquid or vapour often seen spouting up from the sun for thousands of miles. I hold that much of the sun's radiance is due to the impingement on his atmosphere or envelopes of meteoric concretions and less tangible aggregations, down even to ether itself. In fact, there is no other known source from which solar radiation can arise. And the only question is, When did the matter inducing this radiance arrive at the sun? Did it all get there millions or billions of ages ago? Or shall we carry the doctrine of Uniformitarianism to the sun and whole solar system, as I did for the universe in the paper named above?[*] (though the Council had the said portion of it compressed into an abstract at the end). Shall we say that to the sun and other orbs of the solar system materials are arriving now, just as they have been in the habit of doing for millions and millions of years? I have long held this opinion; holding that there still rains a continuous star-shower on the sun's surroundings, and the blaze of that showering radiating from the sun begets light and life in the orbs circulating round him.

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* Vol. x., page 51.

We know that when large meteoric masses come in contact with our atmosphere they get luminous through friction; and if they do not emerge again into interplanetary space they fall to the ground as ærolites—some of them many tons in weight. Now, though the larger masses sometimes fall to the ground in our world, it does not altogether follow that they do so at the sun. The solar gaseous envelopes must be far deeper and far denser than ours are. Ærolites that come in contact with them will seldom (relatively) strike quite perpendicularly towards the sun's centre. Many of them, therefore, after penetrating some hundreds of miles into his surroundings, will arrive at strata approximately corresponding to their own retarded flight, and course round with the rotating strata in which they have thus got imbedded—voyaging, it may be, for weeks or months before being finally vapourised by the hot materials around them. And they must, all the while, be causing in their localities much commotion and diminished radiance, such as might happen on a small scale when green faggots are cast into a charcoal fire, or a huge iceberg is precipitated into a sea of molten cast-iron or white-hot liquid lava. Ærolites, just before entering our atmosphere, must have a temperature likely some hundreds of degrees colder than our ice. One pretty strong argument in support of the meteoric origin of sun-spots is the length of time they endure, extending often over weeks, and sometimes even months. In 1799 a spot was visible again and again for half a year; and Schwabe saw a spot pass eighteen times across the sun's disc—a fact indicating a residence there of more than fifteen months. Surely it cannot be some mere gaseous disturbance, analagous to our cyclones, that can endure month after month in this fashion.

Coming to the conclusion, then, of the possibility, nay, the probability of such an origin for sun-spots, let us next turn our attention to the well-known periodicity observable in the waxing and waning of these solar phenomena—a periodicity first demonstrated by Hofrath Schwabe of Dessau. In my paper of 1875 I brought before you the notion that it is the varying positions of the planet Jupiter, relatively to the sun, which mainly gives rise to the changes in the numbers of the sun-spots—changes which recur again and again with remarkable regularity. Some of you may remember that I then called attention to the direction of the sun's proper motion in space—it may be in his orbit—towards a point in the constellation Hercules — a translatory movement of nearly 150 millions of miles in a year. And as he thus voyages into long unvisited space—unvisited for millions of years—he will naturally sweep up the accumulated dust of ages, the stores of meteoric matter which has either accreted in or migrated to this vast waste of sunless, lifeless space. The planets circle round the sun in a plane approximately about from 50° to 60° of angular distance from the path of his onward march, and will each in each revolution round him cross nearest it, somewhat in front of him, towards one definitely directive point—a point termed "the apex of the solar way." This the closest scrutiny of careful astronomical observations has determined to be about 263¾° of heliocentric longitude and 60° N. P. D.* I assume that each planet as it passes near this longitude will tend to intercept some of the in-drifting meteoroids which would otherwise pass on to meet the sun as he comes bowling along. The amount of intercepting influence will, other things equal, depend on the planet's mass and distance from the sun. Jupiter's mass is more than double that of all the other planets taken together. Besides, it will be an occurrence of exceeding rarity that all of these planets will be at R. A. 263¾° at one time, or rather, I should say, at such a time for each, that a meteoric host starting from Neptune at this longitude would find the other planets successively at the same longitude. For comets starting from Neptune's orbit take six times as long to reach the sun as those travelling from Saturn's, and more than a dozen times as long as those from Jupiter's distance. It appears, then, that Jupiter falls to be the planet which we may reasonably assume to have by far and away the most preponderating influence in this respect. Of course, as said, meteoroids must require some amount of time to journey from Jupiter's orbit to the sun, and therefore the effect of Jovian intercepting influence—if such there be—must take place some time after Jupiter has been at R. A. 263¾° to accord with the hypothesis. Looking at the table and diagrams given below,* it appears very evident that the average sun-spot minimum occurs from two to three years after Jupiter has been at the longitude named. As comets are composed of meteoric matter, let us judge from their rate of travelling as to the rate of travelling of invisible meteoric matter. Now, comets whose aphelia are about as distant from the sun as Jupiter's orbit is, have periods of from five to six years, and will, of course, consume half that time in journeying sunwards; corresponding thus exactly in time with the time that the sun-spot minimum occurs after Jupiter has been at the critical point. Observe, further, that each maximum sun-spot period comes also just six years after each minimum—that is, precisely at the period when, according to the hypothesis, Jupiter's intercepting influence should show least effective, his period of revolution being 11·863 years, or twelve years all but fifty days. I may here quote from a short abstract I read before the British Association at Swansea :—

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[*] See vol. x., pages 61 and 115.

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* Observations vary from R. A. 246° to 266° and N. P. D. 45° to 66°.

"It is well known to all who take an interest in the phenomena of sun-spots that men of science are far from being agreed as to the length of the sun-spot period. I should think, however, that those who wish to prove that our rain, our heat, our storms, terrestrial magnetism, harvests of grain and vintage, with commercial crises, &c., depend a good deal on how much the sun gets his face besmirched, should first of all make sure of the real length of the sun-spot period. To help towards its fixation, I bring under notice the following table, arranged from Wolf's *latest corrected* relative sun-spot numbers, from the year 1770 till 1877, with accompanying diagrams. The numbers are arranged so as to correspond with Jupiter's period of 11·863 years. Each vertical column (save one) commences with the year in which Jupiter's heliocentric longitude is 263¾°. The last column is the summation. . . . . The table and tracings† show, I think, that the sun-spot period is neither 10 years nor 11 years, nor yet 11·1—as assumed by many—but seemingly 11·863 years. It is to this conclusion that I wish to call the attention of meteorologists and others who wish to s correspondence between their various periodicities and those o spots." This I now do, quite irrespective of any hypothesis the physical cause of sun-spot phenomena :—

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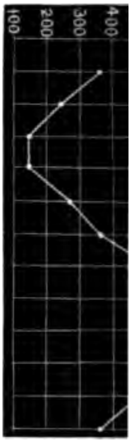
* In Plate IV. the spots near the minimum occurring after 1794 are placed a little too low.

† Plate IV. indicates graphically the numbers of spots for individual years.

Years of Jovian Period.		July 19, 1770.	May 30, 1782.	April 9, 1794.	Feb. 17, 1806.	3 days after 1817.	Nov. 10, 1829.	Sept. 19, 1841.	July 31, 1853.	June 10, 1865.	Summations.
1	.	79	33	34	25	34	54	30	38	31	358
2	.	43	22	22	15	22	59	20	19	16	238
3	.	49	5	15	7	9	39	9	7	7	147
4	.	40	21	8	3	4	22	13	4	37	152
5	.	48	87	4	0	3	8	33	22	74	279
6	.	28	105	10	1	1	11	47	51	139	393
7	.	35	108	18	5	7	46	79	96	111	505
8	.	63	111	39	14	17	97	100	96	102	639
9	.	95	84	58	20	29	111	96	77	66	636
10	.	90	53	65	35	40	83	64	59	45	534
11	.	73	47	75	45	53	68	62	44	17	484
12	.	68	40	50	44		52	52	47	11	364

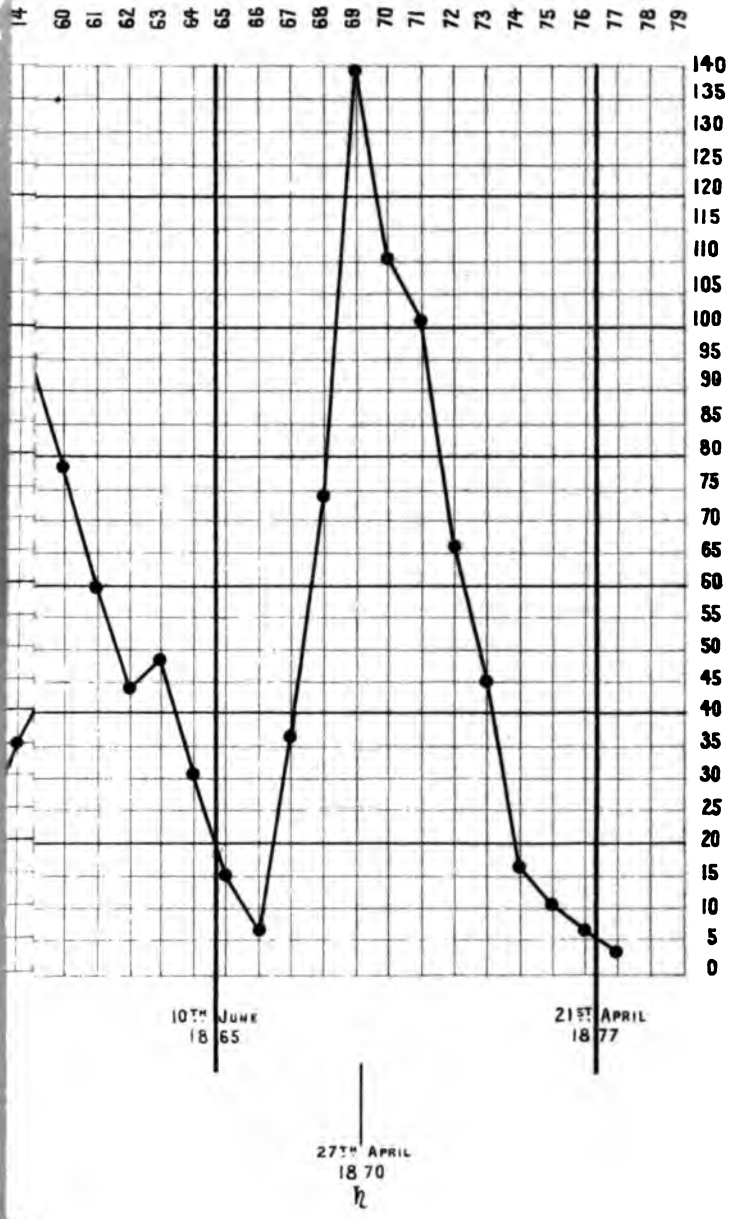
Dec. 29,
1817.



A critic, looking closely into the numbers as arranged i table, may naturally start the obvious objection that, althoug summations come out pretty decidedly in my favour, yet, we take individual years and compare them with some other sponding individual years, startling discrepancies disclose thems For example, choosing the sixth horizontal line of the serie taking the two years nearest the sides, we get 139 and 10 highest number and nearly the next highest number of sun of the whole 107 years; whereas in the same horizontal line the middle, we find 1 and 1—that is, something next door to To this difficulty I can only reply, that it would be unreasona suppose that matter is uniformly distributed throughout either as meteoroids or larger agglomerations. The fact is obviously the reverse, as suns, planets, comets, and meteoric s abundantly prove. It is therefore unreasonable to look for viating regularity among sun-spots when merely disturbed by J

[Plate IV. to face th

WOLF'S RELATIVE SUN-SPOT NUMBERS.



interferences.* It is only by securing a series of years, extending over at least a century, and carefully taking the averages, that we can hope to eliminate non-cyclical irregularities, and set forth the more persistent periodicities, tracing them, it may be, to their source or sources.

Having, however, I hope, established a pretty strong case against Jupiter, to the effect that at a certain specified point in his orbit he is in the habit of abstracting, for his own behoof, packages of fuel that are being conveyed to the sun, let us inquire if there be on record any evidence of goods similar to those amissing being discovered in the possession of the giant planet before he disposes of them, either by conflagration or concealment under the dense mists surrounding his dwelling. On this point there can be little dubiety. Ever and anon large masses or spots, half-hidden in his mists, have been detected—for instance, by Cassini, Shröter, Maïdler, Lord Rosse, Holden, Airy, &c. In fact, some were visible when I wrote these lines (in September). [In *Nature* (November 11) J. R. Capron writes :—"Below the red equatorial belt is a row of four or five small, irregularly-shaped spots, nearly black in tint, resembling sun-spots seen under a low power."]

But it may be cavilled that, granting the hypothesis that the paucity of sun-spots at the minima is mainly due to Jupiter's intercepting influence, then Saturn—a planet of very considerable size—ought to have appreciable effect of a similar character. The fact is, however, that on attempting to construct for Saturn's effects a diagram and table similar to those given for Jupiter, no regularly recurrent influence could be traced.

To the foregoing objection I make answer : It is quite certain that the influence of the sun on cometic matter extends far beyond the orbit of Neptune, even to the distance reached by the farthest recurrent comet. Meteoric matter is continually travelling towards the sun from all points of the compass. In doing so, the particles and larger masses, by converging towards each other as they approach the centre where he is, will therefore come to be more and more densely crowded in space the nearer they get to him, so that each cubic league of space, say, at five hundred million of miles from the sun, will contain much more meteoric matter than each cubic league at double that distance from him. For instance, assuming the decrease in density of material to be approximate to the square of the distance, and directly as the mass, then, since Saturn is nearly twice as distant from the sun as Jupiter, and having only three-tenths of his mass, he would have, therefore, only about one-twelfth the influence on the mass of in-drifting meteoroids. But, on the other hand, the sun's double distance and proper motion, not to mention any initial motion of the meteoroids themselves, would tend to equalize the foregoing disparity to a considerable degree. So that in truth the objection is not hereby fully met. The table given by R. A. Proctor (article "Comet," Dictionary of Science), on the number and density of cometic perihelia relative to their distance from the sun, bears somewhat on this point.

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* And this non-uniformity may be applied to account for torrid and glacial ages. When the solar system passes through a region densely swarming with meteoroids we get what may induce a hot epoch. When there occurs a long protracted minimum, a glacial age may hold reign. Nay, we can imagine some most tremendous star-shower to be the occasioning cause of a so-called world on fire. At times ours may almost look so from the moon.

In consequence of my answer to the objection last stated, another may be brought forward, viz.: If meteoroids travel towards the sun from all points of the compass, then Jupiter will encounter and intercept them in every part of his orbit. I admit this, but beg to point out that when the sun is pressing on ahead of Jupiter at the rate of 150,000,000 miles a year, and, therefore, collecting the great majority of meteoroids—which, of course, gravitate towards him, just as water, corks, and other floating bodies gravitate towards the paddles of an advancing steamer—then, at that point, far fewer will be left for Jupiter to pick up as he comes sailing on behind.

Ere leaving this subject I may notice that the published results of "The Photographic Observations made at the Royal Observatory, Greenwich, for 1878–79," show "that there was a complete absence of sun-spots from November, 1878, till April, 1879,* and a rapid increase in the number of spots and faculæ during the last quarter of 1879, accompanied (in accordance with what had been previously remarked) by an increase in the mean distance from the sun's equator in both hemispheres"—that is to say, that according as the spots tend to increase in number, they at the same time tend to disappear from the neighbourhood of the solar equator. Reflecting on this synchronism, one may draw the conclusion that it is not a very improbable supposition that this disappearance from the equator may be accounted for by assuming that there takes place at the same time an increase in the volume and density of the zodiacal light. It is now pretty generally acknowledged that the latter phenomenon is occasioned by "an immense cloud or zone of meteoroids filling up the space between the sun and the earth." And, granting my interception hypothesis, it will naturally happen that when Jupiter departs from maximum interception of meteoroids gravitating towards the sun, more will be permitted to arrive and form a denser cloud or screen in the sun's equatorial regions, and so tend to prevent our observing sun-spot phenomena in low solar latitudes.

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* In my paper of 1875, I said: "On my hypothesis we may expect the decrement of the sun-spots to go on till some two years after Jupiter's passing nearest the sun's future path in April, 1877."—*Proceed. Phil. Soc. of Glasgow*, vol. x., page 55.

As the late considerable display of sun-spots in the second week of August was accompanied by two fine nights of auroræ here, and much more in Canada, with also great magnetic disturbance over the whole globe, it does not seem to me an improbable supposition that great sun-spot outbursts (such as Secchi figures) projecting, through magnetic disturbance, the zodiacal-light material against our atmosphere may occasion the lighting up of auroræ, which latter rarely appear except during magnetic storms. The increase and diminution in the number of auroræ synchronously with the increase and diminution in the number of sun-spots, as demonstrated by Loomis, point also towards this conclusion.

In connection with the foregoing, I here give an interesting extract from a letter written by Cassini in the 17th century:—"It is a remarkable circumstance that since the end of the year 1688, when this light began to grow fainter, spots should have no longer appeared in the sun, while in the preceding years they were very frequent, which seems to support, in a manner, the conjecture that the light may arise from the same emanations as the spots and faculæ of the sun." Not only is this interesting as an early case of suspected synchronism between the sun-spots and zodiacal light, but further, it testifies to a sun-spot minimum occurring in 1689, and I find that Jupiter was at R. A. 263¾° in the first week of July, 1687: a remarkable proof in favour of my cycle.

The relative arrangement displayed by cometic perihelia may be worth bringing before the notice of astronomers. I have, therefore, taken the two groups A and B given by Mr. Hind in the article

"Comet" in the *Encyclopædia Britannica*, and grouped in c their perihelion points according to their heliocentric longit By this arrangement I find that they largely affect the quad which the sun's line of flight bisects. Further, I have sea through the last half-dozen volumes of *Nature*, and disco thirteen other comets whose perihelia are also given below find these arranged, if anything, even more decidedly in proxi to the sun's path.

HIND'S GROUPS.

Group A.		Group B.	
1. Enke's,	158°·21′	1. Comet 1 of 1866,	6
2. Blanpain's,	67°·18′	2. Stephan's,	7
3. Burckhardt's,	251°·13′	3. Westphal's,	4
4. Tempel's 2nd of 1873,	306°·9′	4. Pon's,	9
5. De Vico's of 1844,	342°·30′	5. De Vico's,	9
6. Brorsen's 3rd of 1846,	116°·2′	6. Olber's,	14
7. Winnecke's,	276°·37′	7. Brorsen's of 1847,	7
8. Pigott's,	50°·17′	8. Halley's,	30
9. Tempel's 2nd of 1867,	236°·9′		
10. Biela's,	109°·9′		
11. D'Arrest's,	319°·9′		
12. Faye's,	50°·3′		
13. Peter's,	240°·7′		
14. Tuttle's,	116°·4′		

GROUP FROM "NATURE."

1. Comet 4 of 1873,	36°·48′	8. Palisa's,	20
2. Swift's,	42°·59′	9. 1st of 1699,	21
3. Tupman's Meteor,	70°	10. 3rd of 1822,	22
4. Hartwig's of 1880 (*d*),	83°	11. D'Arrest's 2nd of 1852,	25
5. Schaberle's,	100°·44′	12. Great of 1880,	28
6. Great of 1577,	129°·12′	13. Hartwig's of 1879,	30
7. 3rd of 1759,	138°·38′		

I have arranged the cometic perihelia in the diagram in circles to obviate overcrowding, Plate V. indicating the their Nos., 1, 2, 3, &c. Those got from *Nature* are p in the outermost circuit, Hind's group A next, and his gro innermost. It requires but a short examination of the dia to observe that it discloses a remarkable symmetry, and at same time an equally remarkable non-uniformity in the arra ment of the cometic perihelia, in reference to the path of the march. The want of uniformity reveals itself in the pauci perihelia taking effect approximately at right angles to the

[Plate V. to face thi

line of flight. Whereas, if we divide the whole circuit by the sun's path (and leave out Tupman's meteor), we have seventeen in each hemisphere—in the hinder quadrants ten each, in the fore quadrants seven each. With, then, so much symmetry, one is naturally led to speculate as to the cause of the paucity of points in what may be termed the flank quadrants. I respectfully submit the following suggestions:—Many comets wandering in space and then falling to gravitate towards the sun, ought, in the course of numerous revolutions round him, to be so acted on by the differential influence of the larger supply of meteorids drifting in a direction relatively against the sun's march, compared with those pursuing a reverse course (as in pacing crowded thoroughfares more people meet us than overtake us), that these comets towards their aphelia must be forced gradually to drop more and more behind the sun, and, therefore, to get gradually more in front of him at perihelia. On the other hand, comets which come to meet the sun nearly face to face will (less those that fall into him), through the continuous advance of the sun towards their aphelia, get the eccentricities of their orbits gradually lessened, and may by and by become such bodies as the planetoids which circulate between Mars and Jupiter, and likely a number more between each pair of the larger planets; while the Moons and Saturn's rings probably came from the same source. Whereas, comets which at present have their perihelia more directly behind the sun, likely have come to meet and course round him immeasurably long after the advent of the progenitors of the planetoids, and so have not yet got the eccentricities of their orbits very much reduced.

I may take this opportunity of saying a few words supplementary and emendatory of the remarks on Terrestrial Magnetism given in Vol. X., pp. 115-118, of our *Proceedings.* Taking for my authority the tables given in Guthrie's Magnetism and Electricity, pp. 329-330, I pointed out that for London* the declination of the compass needle was 0 in 1657—*i.e.*, pointed dead north—and that it reached its western maximum (24° 38′) in 1818. As Jupiter reached R. A. 263¾° about the beginning of that year, if the western maximum did the same then the period would be little more than 160 years. If, again, we suppose the declination to get back to 0 in another 160 years, the two will make 320¼, being half of a complete cycle of 640½ years for terrestrial magnetism to complete the entire circuit. That is on the supposition that there will be a like declination on the east side in a like period—say eastern maximum 1497, 0 1657, western maximum 1818, 0 1978, eastern maximum 2138—in all, 640½ years. And in 640½ years after 1818—in May 2458—Jupiter and Saturn* will both be about 2° from R. A. 263¾°. Well, as I have said, at the beginning of 1818 Jupiter's hel. long. was 263¾°, and I find that 27 of Jupiter's periods amount to 320¼ years, so therefore, on the above supposition, at every occurrence of the eastern maximum, and of the western also, Jupiter's hel. long. will be 263¾°, corresponding to the path indicated by the sun's proper motion in space. It appears further worthy of remark that in 1818 Neptune, our third largest planet, was also at R. A. 263¾°. Nay, more, Neptune was within a few degrees of the sun's path in 1657, the year of zero, and will be so again in 1978, the next epoch of zero declination.

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* "In the year 1818 at London, and generally contemporaneous with that epoch throughout Europe and North Africa, the westerly progress of the north end of the needle ceased, and an easterly movement commenced, and continues to the present time. But in the South Atlantic this period of westerly movement has never ceased."—Lecture on the Magnetism of the Earth (page 28), by Captain F. J. Evans, C.B., F.R.S. It is to the Records at London bearing on this North Atlanto-European region that I confine my attention—Data sufficiently extensive and correct not being obtainable in reference to any other region of our globe.

So much for the combination of these planets in seeming synchronous connection with the horizontal magnetic variations of the compass needle and the sun's orbit or path in space. Let us next look at the apparently combined influence of Jupiter and Saturn in reference to the inclination or dip of the magnetic needle and the said path. The maximum dip was registered at London in the year 1723,† and in that year, about the middle of January, the hel. long. of both Jupiter and Saturn was 263¾°. This, viewed in connection with the facts given above, is surely a noteworthy coincidence in regard to the two planets, whose combined mass is nearly a dozen times more than that of all the other planets added together. Now, I find that if we take 33 of Saturn's periods they amount to 972 years, and that 82 of Jupiter's do the same. If, then, to the year 1723 (when Jupiter and Saturn were at R. A. 263¾°) we add 972, it brings us to the year 2695, and in August 2695, Jupiter and Saturn will again be within 5° of R. A. 263¾. Has this period anything to do with the Saturno-Jovian period of inequality that has given astronomers so much trouble? Be that as it may, I trust I may be excused for taking up your time in pointing out these remarkable coincidences between cycles of sun-spots, magnetic declination and inclination on the one hand, and on the other the connection between the sun's path and the three larger planets, the combined mass of which exceeds that of all the other planets more than two dozen times.

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* In 1818 Saturn was at his western maximum distance from the sun's path.

† If we add 95 years to 1723, the year of maximum dip, it brings us to 1818, the year of maximum westerly declination, and 95 years just equal eight of Jupiter's periods—thus showing a Jovian link between the phenomena of the dip and the declination.

To those who may be disposed to pooh-pooh as absurd the notion that the mere passage of planets across the sun's line of march (ahead of him) is likely to be attended with change in the earth's magnetism, I beg to reply: We are quite certain that the sun influences the magnetism of our globe—our globe which gravitates towards him. It is surely, then, not unreasonable to suppose that the body or bodies towards which the sun gravitates will in like manner influence the sun's magnetism. This being granted, it seems further not very unreasonable to imagine that Jupiter, assisted by another large planet, cutting across the "line of force of magnetism," may disturb to some extent the solar magnetism, and consequently affect also terrestrial magnetism. If they really do so, it is somewhat likely that the sun is moving in an orbit round a primary, and that his orbit is eccentric like that of a comet, not circular like that of a planet: since the line of force of magnetism seems approximate to the sun's line of flight.

Nay, looking on the sun as an enormous comet composed of vast swarm of worlds instead of one single globe, we would be enabled to explain why the sun's density is what it is; and to give reasons for the twenty-six days' terrestrial-magnetic and barometric cycles; while the continuous friction among the many masses would enable us to account for much of the solar light, heat, &c., as well as for some of the perturbations we perceive, and so furnish a text for another discourse on the Uniformitarianism of the universe. Jupiter's density and disturbed appearances may find considerable explanation on the same hypothesis.

A word may be added to those who, like myself, are not astronomers, and before whose mind these subjects come for the first time. They may naturally ask, Why is it that the epoch in terrestrial magnetism seems to occur when the planets are in the neighbourhood of R. A. 263¾°, while the minima of sun-spots take place two and a-half years after Jupiter has been there? A moment's reflection may suffice to show that since the electric current travels somewhat as fleetly as light, and light travels from Jupiter to the sun in something less than an hour, whereas comets take two and a-half years; therefore it happens that while sun-spot minima are delayed two and a-half years after Jupiter's maximum interceptions, a vast meteoroidal swarm plunging into the sun's atmosphere, and stirring up astounding convulsions there, will be followed in a few minutes by thrills of terrestrial magnetism in sympathy with the solar commotion.

Once more, they may ask, If, as you allege, these meteoroids fall by millions into the sun, and have done so for millions and millions of years, where does all this everlasting supply of material come from? And will it continue to come for ever? These queries cannot well be replied to here, but a hint of my views may be obtained from my compressed abstract referred to above. See Vol. X., p. 62, of our *Proceedings*.

[Previous to these pages being in print, I was under the impression that Mr. Waterston was the first to formulate the idea of the meteoric origin of solar radiance (as noted in my paper of 1875); I now find that priority is due in this respect to the late Dr. Robert Mayer of Heilbronn. See Dr. Tyndall's *Heat a Mode of Motion*, sixth edition, page 520.]

III.—*The Chemistry of Sewage Precipitation*.

By Dr. William Wallace.

[Read at the Meeting of the Chemical Section, December 6th, 1880.]

The subject which I purpose to bring before you to-night is one to which, for several years, I have devoted much attention, and I have thought that it might not be uninteresting to the members of the Section to have it introduced to their notice. Although it is with precipitation of sewage that we have to do, yet I trust you will bear with me if I digress at times into collateral branches of the subject.

There are three distinct products of the animal body:—First, there is the gaseous, consisting chiefly of carbonic acid gas and watery vapour, resulting from the oxidation of the respiratory food—fat, sugar, starch, and so on—and this may be called the gaseous refuse or sewage of the body; second, there is the liquid excrement or urine, and this consists essentially of water holding in solution the partially-oxidized products of the waste tissues of the body; lastly, there is the solid excrement, consisting of that portion of our food which has escaped digestion, but altered to some extent by the functions of the body. It is with the two latter alone that we are concerned. They form the most important and essential portion of sewage. But there are other sources of pollution—that is, putrescible matter—besides the animal products. These consist of such things as the water poured off from boiled vegetables and meat, the washings of dishes and kitchen utensils, the water used in washing our own bodies and in washing clothes, the surface drainage of the streets; besides refuse matter of various kinds from workshops and factories, chemical works, breweries, distilleries, and so on. Sewage is thus a very mixed liquid, and this is one of the difficulties of disposing of it. Still, it is a thing we have to deal with, and, such being the case, the question is how to get rid of it in the most convenient, the least injurious, and the least expensive manner.

There can be little doubt as to the original method of disposing of the animal products in what may be called the normal state of existence, when every family lived apart, surrounded by plenty of ground. Yet even in ancient times it was found necessary, for the well-being of the community, as we find described in the Mosaic record, to make sanitary regulations for the proper disposal of the excreta of the camp or household. As families began to congregate into towns the difficulties increased; and it is one of the great evils of town life that no perfect system for dealing with excreta has yet been carried out. If we examine towns where a dry system alone is in operation, as in most of the inland Continental towns, we find that there is a general unsavouriness about them, while the closets are generally odorous to a painful degree. On the other hand, the wet system has evils peculiar to itself, although, upon the whole, a water-closet town is cleaner and less offensive than the other description: yet its underground sewers generate gases, by which the soil is permeated and the houses rendered unwholesome; and the gases escape through imperfect traps and corroded pipes into the houses. If the sewers could all be kept on the surface of the ground, with a constant run of water in them, there would be no danger from this cause; for sewage mixed with sufficient water to ensure it being kept in motion and freely exposed to the air will never become dangerous to health, although it may be more or less offensive to the senses of sight and smell. Perhaps the most perfect town, sanitarily, that we could imagine would be one which had in the centre of every street a copious stream of water running in a perfectly smooth channel, and with sufficient fall to prevent any lodgment of solid matter. Into this stream the sewage of every house would pass, and it might be covered over at intervals, or even throughout its whole length, with a grating so open as to give perfect access of air to the stream below, its bed being only a few inches below the level of the street. It is when excretal matter is shut up that it becomes dangerous to health. Nature has provided for its deodorization and oxidation by mixture with the porous soil and free exposure to the air; and if we defy nature, as it were, by keeping it underground, shut up from the purifying influence of atmospheric oxidation, we must be content to reap the consequences in a class of diseases which appear to be peculiarly the result of the decomposition of excremental matter under these conditions.

A great deal has been said and written about the purifying action of water, but I wish to point out to you that water, *per se*, has no purifying action whatever. If we were to mix excreta with pure or boiled water it would certainly dilute it, but it would not prevent its decomposition and consequent offensiveness in the slightest degree. But water in nature is never pure—it contains in solution both mineral salts and gases, one of which is oxygen, which usually constitutes one-third of the whole. This oxygen in water undoubtedly exerts a most powerful influence on sewage, but then it requires an enormous volume to yield sufficient oxygen to render innocuous a very small quantity of excreta. A gallon of water contains, we may assume, 2½ cubic inches of oxygen gas, but the weight of this is only ·9 of a grain; while, according to my calculation, a gallon of urine would require for its complete oxidation about 3000 grains of oxygen. It is only in extreme cases that we can have the opportunity of mixing animal products with 3000 times their bulk of water; but if we could do so, and provided there was no solid matter to settle down, there would be complete oxidation and purification. In ordinary cases we have to depend more upon contact with the air for the oxidation than the mere mixture of water, which, as I have shown you, possesses but a limited power. With regard to river pollution, the influence of sewage must be considered with reference to quantity. For example, the drainage of a small village somewhere about Tintock would be completely swallowed up and rendered perfectly harmless before it reached Glasgow, but when we throw into the Clyde the excrements of nearly three-quarters of a million of people, we tax the powers of air and water too severely, and the once noble river becomes, at the harbour, a seething puddle, a gigantic cesspool. And yet it has by no means been satisfactorily proved that the condition of the river, disgusting as it is in summer, is directly dangerous to health. The question of the conservancy of rivers is one that has for some time been engaging the attention of sanitary authorities. In the case of a number of towns, such as Bradford and Leeds, the purified sewage is incomparably purer than the grossly-polluted streams into which it flows. These and other towns are subjected to the manifest injustice of being compelled, under heavy penalties, to render their sewage clear, inodorous, and almost perfectly colourless, before discharging it into rivers or streams, which are often, as in the case of the Bradford Beck, literally common sewers of the foulest description. The inhabitants of these towns complain, and with good reason, that in the upper reaches of the rivers wholesale pollution is permitted, while they have been put to great expense in order to accomplish a purification, the effects of which are swallowed up in the filth of other towns over which they have no control. Conservancy Boards to watch over the whole drainage area of the various river basins appear to be the only effectual means of solving the important questions which are so intimately connected—the disposal of sewage and the restoration of rivers to a state of purity.

There are two ways in which excremental matter may be dealt with—the dry system, and carriage by water. The first is the most rational, as well as the most consistent with public health and with national prosperity. The weak part of this system is that, while it disposes of excreta, it leaves untouched all other kinds of sewage, which still require to be removed by means of water-carriage, and demand the same purification before passing into a river as the excreta themselves. While, therefore, upon economical and sanitary grounds, water-closets, especially in houses of the smaller sort, and in public works, jails, railway stations, &c., might, with advantage, be replaced by an efficient dry system, the adoption of this course would not greatly lessen the amount of sewage to be dealt with, or render its purification less imperative.

When water-carriage is used, the following methods may be employed for the disposal of the sewage:—

1st. Running it into the sea, or into a tidal river, under conditions that will prevent its return.

2nd. Irrigation.

3rd. Purification by precipitation—
  (*a*)—by Lime.
  (*b*)—by Sulphate of Alumina.
  (*c*)—by the A B C system.

The system recommended by Sir John Hawkshaw for the disposal of the Glasgow sewage is to pump it up to a high level, and to carry it down to the Ayrshire coast, and then run it into the sea. Perhaps the most serious objection to the adoption of this recommendation is, that it ignores the broad principle that the people of one river basin or drainage area should not be permitted to invade another district, in order to get rid of their sewage, but should restore it to their own river in a form sufficiently purified to prevent nuisance, and allow of the water of the river being used, to a large extent at least, for primary purposes. Apart from the enormous cost of Sir John Hawkshaw's scheme—in itself a serious obstacle to its adoption—it appears unlikely that Parliamentary sanction would be obtained in opposition to the wishes of the inhabitants of a large district with which the city of Glasgow has no connection, and to which it has no legitimate claim. The example of London in running the unpurified sewage into the Thames is scarcely one that can be followed by Glasgow. The average range of the tide in the Thames is 18 feet, while in the Clyde it is only 9 feet 9 inches: the velocity of the ebb-tide is, on the average, on the Thames 2¾ *miles*, while on the Clyde it is only 2¼ *furlongs*, or little more than one-tenth of the speed. When the sewage of London is run into the Thames at Barking and Crossness, during the first three hours of ebb-tide it passes down the river so far, before the tide flows, that it cannot return. This would not be the case in the Clyde, with its small range of tide and sluggish current; and if, therefore, the sewage of Glasgow is to be introduced into the Clyde, it must first be purified either by irrigation or precipitation.

The second method of dealing with sewage is to use it in the irrigation of land, and this system has the double advantage of purifying the water in a more complete manner than can be attained by any process of chemical treatment, and of utilizing, to a certain extent, the manurial value that exists in it. Great hopes were, some years ago, entertained that irrigation was to be the grand solution of the sewage question, and companies obtained from various towns concessions of the sewage for a term of years, as if it were an article possessing an intrinsic value. All that is changed now; some sewage farms, on which immense sums of money have been expended, have been reluctantly abandoned, and irrigation is no longer regarded as anything more than a means of obtaining, where circumstances permit of its application, a good effluent at a moderate outlay. Probably Croydon—a town situated about 25 miles south, or south-east, of London—has the most successful of the sewage farms, and it is no small matter to say that it disposes of the sewage of a population of 60,000 persons at an outlay which is now reduced to about £1000 per annum. But the situation of Croydon adapts it in a peculiar degree to the utilization of its sewage by filtration through land. The quantity of water used in the town per head of population is much less than in Glasgow, and the rainfall not much more than half; no pumping is required, and land is obtained in the immediate vicinity of the town. Again, the land, although not naturally of high quality, is exceedingly well adapted for sewage farming, in consequence of its being of a loose, permeable, character, with a bottom of gravel, which acts as a natural drain and prevents any accumulation of the sewage upon the surface of the ground except under very exceptional circumstances. In cold or moderate weather no odours of a distinctly offensive character are given off; but in some sewage farms, during hot weather, the odour is very disagreeable, and possibly unwholesome.

The quantity of land that appears to be necessary, under favourable circumstances, as at Croydon, is about an acre to each 100 of population, so that Glasgow with its immediate suburbs would require, at the present time, fully 10 square miles of land, and, including the surrounding burghs, about 12 square miles. The greater part of the sewage would require to be pumped to a considerable height, the land (supposing it were possible to obtain it) would require to be held by the Corporation; and, as experience has shown in the case of the Barking farm, large quantities of certain crops would be obtained, which it would be impossible to dispose of to advantage. Again, it is quite certain that the land occupied could never become residential, or be occupied otherwise than by the labourers engaged on the farm. This is even the case at Croydon; although, as already mentioned, the circumstances are there peculiarly favourable to sewage farming.

Purification by chemical treatment has been much misunderstood, and consequently discredited. Because it has not done all that has been claimed for it, some have been inclined to regard it as a failure and unworthy of consideration. Several processes have been advocated for purifying sewage by precipitation, and at the same time manufacturing from the sludge obtained a manure which will be saleable at a considerable price, under the name of native guano, or some other high-sounding title. The purification of the sewage is possible, and has been carried out successfully at Bradford, Leeds, Coventry, Birmingham, and many other towns; but, so far as I have been able to ascertain, the sale of the so-called manure, except in insignificant quantities, appears to have failed of accomplishment. And this is not to be wondered at, for the precipitant, whatever it may be, while it removes the solid matter of the sewage, together with the phosphoric acid, leaves in the effluent water all or nearly all the ammonia, and the potash salts; these constituting by far the most valuable part of the sewage. All hope of making a profit by the sale of the precipitate or sludge should therefore be abandoned; but that is no reason why the process should not be adopted for the purification of sewage.

The matters removed by lime and by alumina, which are practically the only precipitants that have hitherto been employed, are—

Solid matters,
Phosphoric acid,
Fatty acids of soap,
Nitrogenous organic matters,
Vegetable colouring matters,
Magnesia.

The soluble nitrogenous compounds and the ammonia in the effluent soon become oxidized, less rapidly in salt than in fresh water; and the oxidation is greatly facilitated by passing the purified sewage through a porous material, with free exposure to the air, or through sandy or gravelly soil.

Of all the substances proposed for precipitation, the one that appears to be most capable of general application is lime. It can be had everywhere, is cheap, and effects a sufficient purification to enable the effluent to be passed into a non-potable running stream or tidal river, especially if the precipitation is supplemented by filtration through some form of charcoal, or by running it over a limited extent of suitable land, thoroughly drained. It has been objected to the lime process that the effluent soon decomposes, while that from other precipitants, being neutral or faintly acid, resists putrefaction for a much longer time. This is quite true, but it appears to me that the fact that the lime effluent readily oxidizes is entirely in its favour. The organic matter in the purified sewage *must* be oxidized, and the sooner this is accomplished the less likely is it to produce injurious consequences.

Whatever method of precipitation be adopted, it is most important that the sludge should not remain long in the bottom of the settling tanks; whenever it is permitted to remain for a week or two it ferments, throws up bubbles of the gaseous products of decomposition, and serves to render the effluent offensive—producing, in fact, the very evils so noticeable in the harbour of Glasgow, where the solid portion of the sewage of the city settles down to the bottom, and undergoes putrefactive decomposition. The mud dredged from the Clyde, nearly opposite Lancefield, gave the following results on analysis :—

Water, ...	11·44
Organic Matter, ...	12·31
Phosphoric Acid, ...	·80
Sulphuric Acid, ...	·20
Lime, ...	1·32
Magnesia, ...	1·30
Oxide of Iron, ...	5·23
Alumina, ...	3·54
Sand, &c., ...	63·78
	99·92

Phosphate of Lime, ...	1·74
Nitrogen, ...	·47
Equal to Ammonia, ...	·57
Sulphur in organic matter and combined with Iron,	·28
Calculated value, per Ton, ...	10/6

If we compare this with the sludge obtained by precipitation we will find that, except for the extra quantity of sand, there is a very striking similarity of composition.

Among the towns where precipitation is in use, none is more worthy of attention than Leicester, the population of which is about 120,000, while the sewage amounts to 7,000,000 gallons per day. It was here that the first attempt was made to purify sewage by precipitation, lime being the agent employed. After 25 years' experience, during which a great many processes were tried, the authorities came back to lime, which they consider the only possible precipitant for the sewage of a large town. The quantity of lime used is 20 to 30 cwt. per million gallons, and nothing is obtained for the sludge, which has hitherto been employed, almost exclusively, in making up land in the immediate neighbourhood of the works. The cost of working, for lime, fuel, and labour, is £2,200 per annum. As regards the practical results obtained by the purification of the Leicester sewage, these are not entirely satisfactory, but the conditions existing in the town are altogether exceptional and peculiar. The river Soar, into which the effluent runs, has been canalized, and the flow is said to be only a mile a day in dry weather, while in wet weather it may be ten times as much. Then the effluent forms a very large proportion of the whole contents of the river or canal during dry weather, probably the greater part of it; and above all, there exists in the town a separate system of drains for the rainfall, and all the filth of the streets is washed into the Soar without purification. Lastly, a small low-lying part of the town has, until recently, been kept out of the general drainage system. It is therefore not surprising that, while the bed of the river is kept perfectly clean, and there is no odour perceptible in or near the town, the water four miles down is slightly offensive during dry and hot weather. The sludge, containing about 30 per cent. of water, amounts to about 12,000 tons per annum. The whole of the sewage requires to be pumped 26 feet. The precipitation is effected in a series of very large tanks and settling ponds, and the effluent is further purified by filtration through an osier bed three acres in extent.

In Birmingham lime has always been the precipitant employed, and a great improvement has been effected in the condition of the river Tame, yet the results are not so satisfactory as they might be if a somewhat different system of working were adopted. The sewage, after receiving its dose of lime, passes through a series of settling tanks; but as the lime precipitate is so light that it will not settle completely unless the water is absolutely at rest, it follows that the effluent is always more or less turbid. I consider it imperative that, where lime is used as the purifying agent, the effluent be further subjected to filtration, either through land, where it can be had of a suitable nature, or through "breeze" or some other suitable material. This fact is now recognised by the Birmingham authorities, who expect in future, by a system of land filtration, to produce a more perfect effluent than they do at the present time. There is a farm of considerable dimensions in connection with the sewage works, the principal use of it being for the disposal of the sludge, the quantity of which is enormous. It is got rid of by covering the ground with a layer of it, and then digging it in. Excellent crops of certain vegetables are produced. Formerly works were in operation to carry out the processes of General Scott for the manufacture of cement from the sludge, and for the treatment of night-soil, but both of these have been abandoned.

In Leeds, where the "A B C" and several other processes have been tried, lime alone is now used, and the results are considered satisfactory so far as the effluent is concerned, although it is not subjected to any description of filtration. Its condition, however, is of the less consequence, since, under any circumstances, it is likely to be purer than the water of the Aire, into which very dirty river it is admitted. Here, as elsewhere, the sludge is the chief difficulty: it is indeed the *bête noir* of sewage purification everywhere, and no town or city should adopt a system of precipitation until it is clearly seen how the sludge is to be disposed of. No matter how it is made or what it contains, it cannot be sold; nor will farmers take it for the lifting in its wet state, except in insignificant quantities. An attempt was made in Leeds two years ago to convey away the sludge in barges; but the way in which it was carried out clearly showed that those in charge had no correct conception of the difficulties connected with the process. No sludge is now dried at Leeds, for the obvious reason that the drying costs more than can be obtained for the finished article. On the other hand the cost of working the precipitation is now much less than it was formerly. Four or five years ago the materials for a modified "A B C" process cost at the rate of 18s. 3d. per hour, while now a quantity of lime (7 tons), costing about £5, suffices for the whole 24 hours. The effluent is satisfactory unless when the sewage is mixed largely with tanners' refuse, when it is of a distinctly brown tint, which lime will not remove. The quantity of sewage averages about 9 million gallons per day, but is sometimes much more.

In Bradford, where lime alone has been used for several years, the average flow of the sewage is 8 million gallons per day. The works are capable of dealing with 10 million gallons; but if, by reason of heavy rainfall, this quantity is exceeded, the surplus is passed direct into the Beck, a stream of extraordinary filthiness, which is not likely to be further contaminated by it. The system of precipitation pursued in Bradford differs from any I have seen elsewhere, in this respect, that the sewage does not run continuously into and out of the tanks, but these, which are of comparatively small dimensions, are filled and emptied every hour or so, and the sewage is allowed about three-quarters of an hour of absolute quiescence, during which the precipitate settles down completely. The effluent is passed through or over breeze (riddlings of gas coke), whereby its composition is greatly improved, and it passes into the Beck quite clear, and only faintly coloured by dye-stuffs. I have made analyses of the effluent as first produced, and after passing through the filtering material, and the results show that not only is all suspended matter removed, but also that the free lime (so injurious to fish when introduced into a river), is almost all carbonated, and for the most part removed. If we compare with this the composition of the Bradford Beck, taken above the sewage works, it will be seen that it must be considerably improved by the admixture of the purified sewage. Experiments on the large scale at Bradford have shown that, in order to obtain satisfactory results, it is necessary to employ a lime of the best quality. The sludge has hitherto been used exclusively in the making up of waste land in the vicinity of the works, but experiments are now being made with the object of reducing it to a more portable form, so that it might realize the cost of carriage to some distance. Although the treatment of the sludge after it is deposited in the precipitating tanks is not all that can be desired, the Bradford works are, on the whole, the best I have seen, and are well worth the study of any Corporation who purpose to adopt precipitation as the means of purifying sewage.

In Bolton, lime is used in conjunction with a certain proportion of carbonaceous matter, and the results are stated to be satisfactory. Owing to the flooded condition of the river, the works were at a stand-still when I visited the town on two occasions. I have, however, ascertained the composition of the dried sludge and the effluent water.

In Windsor the process of Mr. Fritz Hillé is followed. It is a modification of the lime process, "chemical salts" (chiefly chloride of magnesium), and a small quantity of tar being added along with the lime. The "salts" are stated to hasten the deposition of the sludge, while the tar retards the decomposition of the effluent. In the ground connected with the works, which are situated at "The Ham," about three miles from the town, trenches are dug, into which the sludge is run, and as the soil is gravelly the liquid portion readily passes away, leaving the mud in a state in which it can be handled. The composition of the sludge is not essentially different from that obtained with lime alone, and, indeed, contains much less magnesia than that produced at Leeds and Bradford, where, probably, magnesian salts are largely employed in finishing and weighting woollen goods and mixed fabrics. The effluent is further purified by irrigation or land filtration. The ordinary quantity of sewage is 1½ million gallons per day. The tanks and other apparatus are very well arranged. Tottenham and some other places are also worked on Hillé's system.

Coventry has been working for some years under Dr. Anderson's patent, in which sulphate of alumina, with enough lime to throw down the alumina, is employed. At present the works are in the hands of the Rivers Purification Company, to whom the city pays £2,200 per annum for the treatment of the sewage, which amounts to 2 million gallons per day. The condition of matters here is very much the same now as they were when I visited the works some years since, except in this respect, that all hope of selling the sludge, except for the merest trifle of remuneration, appears to be now at an end; the drying is abandoned, and the sludge is got rid of by spreading on fields, &c. The use of sulphate of alumina is interesting, as it is really the only competitor with lime. The quality of the salt used at Coventry is of the crudest and poorest description; and as the effluent is very good, it shows that a material of the cheapest kind may be successfully employed. No doubt the process, under any circumstances, must involve a greater outlay than if lime were employed, but I consider that this is counterbalanced, to a very considerable extent, by the diminished quantity of sludge to be disposed of. If the phosphoric acid be accepted as the measure of the manurial strength of the sludge, it will be seen, on comparing the various analyses, that the article produced in works where sulphate of alumina is the precipitant is from twice to three times as strong as that precipitated by lime: in other words, the quantity of sludge is from twice to three times as great in the latter case as in the former, while the effluent from sulphate of alumina is at least as good as that from lime, and does not require, so imperatively, subsequent filtration through gravelly soil or breeze. Then, again, if there is any hope of disposing of the dried or partially dried sludge by sale to farmers, there is a far greater probability of doing so if the calculated value per ton is from 20s. to 27s., as at Coventry, than if it were only from 11s. to 15s., as it is in various places where lime alone is used as the precipitant. In Coventry there is used, along with the sulphate of alumina, a small quantity of copperas (sulphate of iron), and enough milk of lime is afterwards added to make the liquid faintly alkaline. The exact quantities are, for 1,000,000 gallons, 15 cwt. sulphate of alumina, 2½ cwt. copperas, and 6½ cwt. lime. The sewage then passes on to the precipitating tanks, of which there are four, each capable of containing 225,000 gallons, and they are wrought on the continuous system, three being always in use, while the fourth is being cleared out. The precipitate goes down rapidly, much more so than when lime alone is used, and the effluent passes off in a constant stream in a fairly purified condition, but usually of a faint rose colour arising from the dye-stuffs present in large quantities in the sewage. It is afterwards passed through 9 acres of land laid off as a filtering ground, and separated into portions which are wrought intermittingly. These plots are cropped with mangolds, rye-grass, &c., and a portion is planted with osiers, which grow vigorously and yield a good return. The effluent passes into the river Sherbourne at the lowest part of the ground, thoroughly purified from suspended matter and quite inodorous, but still of a faint rose tint.

In Aylesbury the process of the A B C Company has been adopted. The sewage looks very foul, and although on both occasions when I visited the town the works could not deal with the whole of it, that portion which was treated produced an excellent effluent. The substances used for purification are sulphate of alumina and charcoal, with or without the addition of clay. No lime is used, as the sewage contains enough free ammonia to decompose the sulphate of alumina. The sludge is pumped up to a tank on the roof of the buildings, and brought down by a pipe into a filter-press, in which the water is reduced from 90 or 95 per cent. to 50 per cent. It is now in the form of cakes which, when kept in a store or in the open air during dry weather, become dry to the touch, and when ground form "native guano," which is sold for £3 10s. per ton, the calculated value being, however, only 33s., while the selling price, comparing it with farm-yard manure, should be less even than this. The cost of production is given by Mr. Henry Robinson, C.E., in his paper on Sewage Disposal, 1879, as follows:—Chemicals, labour, &c., £1 12s.; drying, &c., 5s. 8d.; grinding and bagging, 15s.—in all £2 12s. 8d. per ton. This process suits very well for a small population, such as that of Aylesbury (about 6000), situated in the middle of a rich agricultural district, where a small quantity of artificial manure may be disposed of by active agents or by extensive advertising; but it does not appear to be applicable to a large town, where it would be impossible to dispose of more than a trifling quantity of the sludge, and there would be, therefore, nothing to counterbalance the heavy outlay for chemicals. Besides this, it would be impossible to obtain, in sufficient quantity for a large town, the carbonaceous matter, which is an essential ingredient in the process. This is a bye-product in the manufacture of prussiate of potash, and the production of it is limited. I do not know any other kind of charcoal, suitable for the purpose, that could be had except at a cost that would preclude its use for sewage purification.

The separation of the sewage proper, and especially that from water-closets from the surface drainage, has been brought prominently before the citizens of Glasgow, and I consider it necessary to make a few remarks on the subject. It is supposed by some that if the products of the water-closets were kept distinct, amounting, say, to a million gallons a-day, all the other drainage of the city might be passed into the river without danger of causing a nuisance. But I have shown conclusively, by chemical analyses, that the drainage from districts where there are no water-closets is very nearly as foul as that from those provided with those conveniences. The latter use a much larger quantity of water, and this dilution compensates, or nearly so, for the extra amount of impurity. A little consideration will show that, practically, all the water used for domestic purposes is, and must be, more or less foul, and requires purification before being introduced into a river. For example, no liquid enters more readily into putrefaction than the water in which cabbage and other vegetables have been boiled;

and the washing of cooking utensils gives rise to very foul water. In fact, kitchen slops of all kinds are very impure, and the soapy water resulting from the washing of clothes is, in many cases, nearly as bad. In the houses of the industrial classes the kitchen sinks are freely used for purposes for which they were never intended; and, in fact, with the exception of the solid excrement, the sewage contains practically all that is found in that produced in water-closet districts. It comes to this, then, that under the separate system, properly carried out, all that is saved from going into the sewers is the rainfall. In Leicester, where two distinct sets of drains exist, the quantity of sewage from a population of 120,000 is 7 million gallons a-day; and the somewhat unsatisfactory condition of the Soar in hot weather is considered to be due, at least in part, to the fact that the street washings pass into the river without purification.

As regards the system of precipitation which it is desirable to adopt in the case of Glasgow, I do not consider it imperative that this point be settled before proceeding with the works. For both systems—that using lime and that in which sulphate of alumina, with or without lime, is employed—the same tanks, apparatus, and filtering beds are required, the only difference being that when the latter process is used, the filtering beds do not require to be quite so extensive as when lime is the precipitant. Glasgow is well situated for both processes: lime of the finest quality can be had at from 12s. to 14s. per ton, and probably, from the dilute nature of the sewage, 15 cwt. per million gallons would suffice; on the other hand, a crude sulphate of alumina, containing also some sulphate of iron, could be made here from the waste shale of our coal-fields at a very low price, and the use of this precipitant would keep down the quantity of sludge. The disposal of this substance is one of the most important considerations in the establishment of sewage precipitation works. There is a vast quantity of waste land on both sides of the river which might be reclaimed and rendered valuable by means of the sludge, and I see no reason why it should not be sent off to considerable distances by railway, as is done at present with the town refuse, to enhance the value of arable land. By having several precipitation works, facilities would be given for conveying the sludge in various directions.

Whatever system of precipitation be adopted, the disposal of the sludge is one of the most important elements in the calculation of cost. I have estimated that the sewage of Glasgow—40 to 70 millions of gallons daily—will produce a quantity of sludge which, in the dried state, would amount daily to 135 tons; but as it must be dealt with in its moist condition, it would be a fair estimate to take five times this, or 675 tons, as the quantity to be daily got rid of. If lime alone were used as the precipitant, an average of about 40 tons would be required daily, which, at 12s. per ton, would cost £24 a day, or £8760 per annum. The total cost of working the precipitation process, not including interest on works, would probably amount to somewhere about £25,000 per annum.

The question whether the effluent from precipitation will putrify and cause a nuisance after mixing with a considerable proportion of clean river water, is one which has engaged my attention, and I am glad to be able to say that the results have been satisfactory. I cannot do better than quote a few sentences from a report recently made to the Magistrates and Council of Glasgow, and which has been published as an appendix to a report by the deputation which visited a number of English towns last summer.

Experiments were made during July and August on the oxidizing power of river water on purified sewage. An average Glasgow sewage was prepared by mixing 2 parts of Portland Street (water-closet) with one part of Reid Street (non-water-closet) sewage, and this was divided into three portions, and defecated—

A, by mechanical means only.
B, by precipitation with lime.
C, by precipitation with sulphate of alumina.

In the effluents the amount of free and organic ammonia was estimated, and 12 parts of clean Clyde water added, after which each sample was divided into two, one-half being placed in an open glass bottle, and the other in a closely stoppered bottle. After the lapse of five weeks, the ammonia was again estimated, when it was found that in every case the oxidation was all but complete, and that it went on as well in closed as in open vessels. The original mixed sewage, or rather the clear portion of it, contained 6·18 grains per gallon of free and ·233 of organic or "albumenoid" ammonia; after treatment with lime the respective quantities were 5·950 and ·056, and after sulphate of alumina, with a certain quantity of lime (Coventry process), they were 5·880 and ·042.

The following statement shows the proportions of free and organic ammonia in the mixtures of sewage and clean water at the commencement of the experiments and after five weeks:—

	Settling or Filtration.			Purification by Lime.			By Sulph. of Alumina.		
	Original	5 Weeks in		Original	5 Weeks in		Original	5 Weeks in	
		Open Bottle.	Closed Bottle.		Open Bottle.	Closed Bottle.		Open Bottle.	Closed Bottle.
Free Ammonia,	·487	·0024	·0021	·470	·0017	·0012	·465	·0011	·0011
Organic do.,	·023	·0091	·0087	·009	·0056	·0053	·008	·0049	·0078
Total,	·510	·0115	·0108	·479	·0073	·0065	·473	·0060	·0089

If the proportion of free and organic or "albumenoid" ammonia be accepted as the measure of the amount of pollution, these results show that in five weeks, at least in the cases where defecation was effected by precipitation, the whole of the added pollution in the form of sewage had disappeared, and the water had acquired a degree of purity equal to that of the Clyde above Glasgow. Even in the sewage purified by filtration, only 2 per cent. of the ammonia remained unoxidized. Experiments showed that the ammonia was converted first into nitrous, and finally into nitric acid, combined in both cases, of course, with bases (lime, magnesia, soda). In the case of the filtered sewage, kept in a closed bottle, the amount of nitric acid was found to be 1·63 grains per gallon, equal to ·513 of ammonia. The amount of ammonia which had disappeared during the experiment was ·499, so that it must be concluded that the oxidation had already begun before the original estimation was made. In this series of experiments the effluents obtained by precipitation were practically inodorous, and after being mixed with the Clyde water they did not at any time acquire an appreciable odour. An experiment begun in 1879, in which crude sewage was mixed with 8 times its bulk of clean water, and the mixture kept in a loosely covered vessel, showed that even in a year the impurities did not disappear, and all the time there was abundance of fungoid growth. In none of the experiments where the defecated sewage was mixed with 8 or 12 times its bulk of clean water was there any growth of sewage fungus observed.

An experiment of similar character begun on 12th August showed that, during warm weather at least, the oxidation is very rapid. Some average Glasgow sewage was defecated by lime (in the proportion of one ton per million gallons), and mixed with 12 parts of clean Clyde water, and the result was tested on 1st September, with the following results:—

	Defecated Sewage.	Mixture, 20th August.	1st Sept.
Free Ammonia, - -	5·320	·4220	·0014
Albumenoid do., - -	·063	·0094	·0070
Total, - -	5·383	·4314	·0084

The mixture on 1st September contained a large proportion of nitrous acid, showing that, although the ammonia had almost disappeared, the oxidation was not yet complete. Subsequent experiments during colder weather showed that the rapidity of the oxidation depends much upon temperature, the process being decidedly slower in cold than in warm weather. If, as is asserted by some authorities, and as my own observations indicate, the process depends mainly upon the presence of *bacteria*, it is easy to understand that the oxidation or, as it may be called, nitrification, will be more rapid in warm than in cold weather.

The result of all my experiments and observations is that Glasgow sewage, properly defecated and introduced into the Clyde at a point below the City, will not, under any circumstances, give rise to a nuisance.

The question whether lime or alumina is the more effective agent for the precipitation of sewage has engaged my attention, and the results of my observations appear to indicate that, although the alumina produces a somewhat more satisfactory effluent, the advantages obtained by its use are not sufficient to compensate for the greatly increased cost of purification, which may be set down at about four times that of lime. If, however, a very cheap variety of sulphate of alumina, with some sulphate of iron, can be obtained, or if the liquor obtained by lixiviating calcined alum shale is available; if, in fact, the cost of alumina, or a mixture of alumina and oxide of iron, could be approximated to that of lime, I would have no hesitation in recommending its use in preference to lime.

Mr. Peter Spence, of the Pendleton Alum Works, near Manchester, has proposed a very ingenious system for the purification of sewage and the utilization of one of its constituents. The sewage is first treated with lime, and the nearly-clear effluent mixed with a solution of sulphate of alumina, which throws down albuminous compounds combined with alumina, while at the same time the free lime in the effluent is neutralized. The alumina precipitate is then treated with a sufficient quantity of sulphuric acid to combine with the alumina, forming a sulphate which can be used over again, when the albuminous matter is separated in flakes, which are collected, dried, and distilled, and the ammonia produced converted into sulphate. A careful experiment with one gallon of sewage from Portland Street sewer gave 1·5 grain of albuminous matter, retaining ·57 or nearly one-fourth of the whole alumina, and containing ·078 of a grain of nitrogen, equal to ·38 of a grain of commercial sulphate of ammonia. 30 million gallons of such sewage would, therefore, yield by this process 1629 lbs. of sulphate of ammonia, worth about £13. On the other hand, there would be required about £90 worth of sulphate of alumina, a certain portion of which would be lost at each operation, and about £30 worth of sulphuric acid, so that the sulphate of ammonia would not go far in covering the extra expense of the process as compared with a simple precipitation by lime. Besides this, extra tank accommodation to a large extent would be required to work the process, which appears to be of too complicated a character for practical sewage precipitation. It is only right to state, however, that Mr. Spence, in his experiments with Birmingham sewage on a more extensive scale than mine, shows a larger yield of ammonia and less loss of alumina.

A process for the extremely rapid oxidation of the effluent from precipitation by lime or alumina, by which it would be rendered entirely innocuous before being introduced into the river, and that at trifling cost, has been brought before me, but I am not at present at liberty to disclose the name of the inventor or the details of the process. I trust that it will be brought before the society by the inventor during the present session.

It now only remains for me to refer to various tables of analyses connected with sewage precipitation which I propose to append to this paper, should it be considered of sufficient interest and importance to be published in the *Proceedings* of the Philosophical Society.

Analysis of Crude Sulphate of Alumina used at Coventry for Sewage Precipitation.

Sulphate of Alumina, ...	10·75
Sulphate of Iron, ...	·99
Sulphate of Lime, ...	·75
Sulphate of Magnesia, ...	2·01
Sulphate of Soda, ...	4·97
Sulphuric Acid (free), ...	2·02
Water, ...	41·84
Insoluble Matter, ...	37·32
	100·65
Alumina, ...	3·23

ANALYSIS OF ALUMINO-FERRIC CAKE.

Sulphate of Alumina, ...	47·62*
Sulphate of Iron, ...	·58
Sulphate of Lime, ...	·53
Sulphate of Magnesia, ...	·39
Free Sulphuric Acid, ...	1·04
Insoluble Matter, ...	·16
Water, ...	49·31
	99·63
*Containing Alumina, ...	14·30

COMPOSITION OF CALCINED ALUM SHALE, HURLET.

SOLUBLE PORTION—	
Alumina, ...	3·30
Peroxide of Iron, ...	9·90
Lime, ...	·67
Sulphuric Acid, ...	21·66
INSOLUBLE PORTION—	
Alumina, ...	9·78
Peroxide of Iron, ...	20·68
Lime, ...	1·25
Sulphuric Acid, ...	7·81
Silica, ...	24·72
	99·77

Analyses of Sewage Sludge (Air-Dried).

Name of Town.	Aylesbury.	Birmingham.		Bolton.	Bradford.		Coventry.		Leeds.		Leicester.	Windsor.
Process of Precipitation.	A B C	Lime. 1	2	Lime and Charcoal.	Lime.		Sulph. of Alumina.		Modified A B C	Hanson's Process.	Lime.	Hille's Process.
Date.	1879.	1879.	1879.	1879.	1876.	1879.	1877.	1879.	1876.	1876.	1879.	1879.
Water,	12·60	12·70	13·16	14·34	8·90	6·92	14·04	10·04	9·56	16·40	11·93	11·76
Organic Matter, Carbon, &c.,	35·00	19·19	20·04	26·18	33·75	34·53	20·58	23·09	20·82	27·92	22·18	12·06
Phosphoric Acid,	2·11	·40	·72	·62	·80	·73	1·56	2·07	·64	·75	1·21	·87
Sulphuric Acid,	2·70	1·45	·35	·61	·64	1·74	1·32	·56	2·15	1·02	·51	·49
Carbonic Acid,	...	7·62	8·53	8·30	10·53	13·77	6·64	5·71	8·42	13·11	15·25	22·71
Lime,	2·18	11·19	12·74	14·50	16·90	20·27	9·16	6·65	9·68	17·51	20·16	31·09
Magnesia,	·18	·90	1·37	1·06	1·66	5·07	·86	·61	5·64	7·67	1·48	1·58
Oxide of Iron,	6·20	2·70	3·20	1·98	2·11	2·01	4·14	2·66	4·61	2·32	2·66	1·68
Alumina,	6·75	2·68	2·58	2·97	3·49	3·89	4·13	5·80	7·04	6·30	1·63	2·31
Sand, &c.,	33·50	41·13	37·93	29·50	21·80	10·23	37·83	42·00	31·60	7·36	22·30	14·16
	101·22	99·96	100·62	100·06	100·58	99·16	100·26	99·19	100·16	100·36	99·31	98·71
Phosphate of Lime,	4·61	·87	1·57	1·35	1·74	1·59	3·40	4·52	1·39	1·64	2·64	1·90
Nitrogen,	1·60	·52	·49	·61	·62	·66	·92	1·27	·66	·70	1·08	·52
Equal to Ammonia,	1·94	·63	·60	·74	·76	·80	1·11	1·55	·80	·84	1·31	·63
Calculated value, per ton,	33/	10/9	11/5	13/4	15/1	15/4	20/	27/2	14/2	17/2	21/7	11/5

Clyde at different Depths and States of the Tide.

The figures represent grains per gallon of Water.

	LOW-WATER.			HALF-FLOOD.			HIGH-WATER.			HALF-EBB.		
	Depth in Feet.	Total Solids.	Common Salt.	Depth in Feet.	Total Solids.	Common Salt.	Depth in Feet.	Total. Solids.	Common Salt.	Depth in Feet.	Total Solids.	Common Salt.
GLASGOW BRIDGE, 13th October, 1879.	Surface.	15·96	3·68	Surface.	15·96	4·39	Surface.	·26	4·27	Surface.	17·22	4·96
	3½	16·10	3·68	6	20·16	5·42	7	15·54	4·27	5	16·94	4·96
	7	17·78	4·15	12	20·58	5·89	14	15·12	4·27	10	18·20	5·08
	10	17·78	4·27	18	16·80	4·74	21	14·98	4·27	15½	17·22	5·08
GOVAN FERRY, 2¼ miles down, 14th October, 1879.	0	21·14	4·84	0	18·20	4·03	0	18·06	4·03	0	19·46	5·30
	6	21·14	4·84	7	18·20	4·03	8	17·08	3·80	6½	19·46	5·30
	12	21·28	4·96	14	18·20	4·03	16½	18·20	3·92	13	19·60	5·42
	18	21·14	4·96	21	17·78	4·03	25	18·20	3·92	20	20·02	5·42
RENFREW FERRY, 5½ miles down, 15th October, 1879.	0	17·64	5·30	0	16·10	4·61	0	18·84	4·34	0	16·38	4·61
	5	17·12	5·41	6½	16·24	4·61	8	17·50	3·92	7	16·24	4·72
	10	17·64	5·30	13	16·24	4·61	16½	18·06	3·92	14	16·38	4·61
	15	17·78	5·18	20	16·24	4·38	25	16·80	3·08	21	16·80	4·61
ERSKINE FERRY, 9½ miles down, 16th October, 1879.	0	28·00	5·20	0	44·8	28·87	0	218·4	179·02	0	47·6	34·65
	6	21·00	4·85	7½	54·6	35·80	9	266·0	218·29	7½	57·4	40·42
	12½	29·40	5·31	15	54·6	38·11	18	295·4	241·86	15	61·6	47·20
	19	29·40	5·54	23	56·0	34·65	27	310·8	265·34	23	66·5	48·51
DUMBUCK LIGHT, 13 miles down, 17th October, 1879.	0	117·6	94·71	0	520·8	455·07	0	1107·4	949·41	0	799·4	695·31
	5	119·0	96·52	6½	639·8	540·54	9	1153·6	984·06	6½	795·2	693·00
	10	119·0	96·52	13	674·8	591·36	17½	1233·4	1069·53	13	802·2	697·62
	15	123·9	99·33	20	729·4	600·60	26	1293·6	1131·90	20	823·2	693·00

COMPOSITION OF RAW AND PURIFIED SEWAGE FROM VARIOUS ENGLISH TOWNS.

Grains per Gallon.

	In Solution.											Sedimentary Matter.		
	Total Solids.	Saline Matter.	Organic Matter, &c.	Chlorine.	Equal to Chloride of Sodium.	Oxygen required to oxidize Organic Matter.	Ammonia.			Nitrites.	Free Lime.	Total.	Mineral.	Organic.
							Free.	Organic.	Total.					
Bradford Sewage, - - -	52·64	41·16	11·48	4·13	6·80	·980	·840	·161	1·001	...	...	33·32	12·34	20·98
Do. do., after lime,	124·60	110·60	14·00	4·34	7·15	1·015	·875	·168	1·043	large.	54·58	146·90	114·80	32·10
Do. do., effluent from tank, - - - -	91·28	82·74	8·54	3·64	6·00	1·190	·470	·105	·574	do.	32·06	...	...	...
Bradford Sewage, filtered through "breeze," -	61·04	53·62	7·42	3·64	6·00	1·120	·420	·098	·518	do.	14·76	4·01	4·01	...
Leeds Sewage, - - - -	48·58	39·34	9·24	5·53	9·12	·875	1·085	·182	1·267	...	...	24·37	9·87	14·50
Do. do., mixed with lime, - - - - - - -	42·42	35·42	7·00	6·16	10·15	·840	1·085	·168	1·253	considerable.	2·08	36·84	25·18	11·66
Leeds Sewage, effluent from 6th tank, - - - -	33·32	28·56	4·76	4·76	7·85	·682	·560	·105	·665	large.	1·01	3·95	3·95	...
Leeds Sewage, final effluent,	34·86	29·26	5·60	4·69	7·73	·952	·525	·105	·630	do.	1·01	2·46	2·46	...
Tottenham Sewage, - - -	59·50	47·18	12·32	5·39	8·88	·770	3·010	·322	3·332	...	...	21·10	10·00	11·10
Do. do., effluent,	53·90	43·54	10·36	4·34	7·15	·560	1·400	·154	1·554	small.	4·98	5·55	3·02	2·53
Birmingham Sewage, - -	102·34	80·64	21·70	21·77	35·92	8·512	2·415	·476	2·891	...	...	31·23	16·129	14·94
Do. do., effluent,	55·72	47·18	8·54	12·18	20·09	1·386	1·470	·175	1·645	small.	3·04	·92	·68	·24

Birmingham Sewage, from land irrigation, - -	50·26	38·50	11·76	5·74	9·47	·175	·201	·042	·243	considerable.	10·59	trace.	...	...
Birmingham, River Tame, above Sewage Works,	53·20	45·64	7·56	6·37	10·51	·168	·112	·042	·154	do.	...	14·25	11·11	3·14
Coventry Sewage, - - -	41·30	33·88	7·42	4·83	7·97	·423	1·820	·196	2·016	trace.	...	14·81	6·48	8·33
Do. do., effluent,	45·22	38·08	7·14	3·43	5·66	·294	·805	·098	·903	considerable.	...	2·65	1·42	1·23
Do. do., do., after filtration through land, - - - - - -	44·94	38·78	6·16	3·85	6·35	·178	·647	·035	·682	do.	...	3·58	2·90	·68
Windsor, effluent, - - -	42·42	35·70	6·72	4·41	7·29	·350	1·820	·119	1·939	...	6·12	3·70	2·22	1·48
Do., after land filtration,	42·42	34·16	8·26	4·41	7·29	·375	·980	·105	1·085	considerable.	6·58	...	...	...
Aylesbury Sewage, - - -	49·14	40·74	8·40	4·97	8·19	·700	3·430	·147	3·577	...	...	594·98	456·73	138·25
Do. do., effluent from 1st tank, - - -	48·86	41·58	7·28	4·55	7·50	·385	1·470	·126	1·596	...	...	·98	·46	·52
Aylesbury Sewage, effluent from 2nd tank, - -	48·02	42·42	5·60	3·85	6·35	·245	·980	·126	1·106	...	...	·55	·31	·24
Aylesbury Sewage, final effluent, - - - - -	49·98	44·38	5·60	4·06	6·69	·231	1·190	·112	1·302	...	...	...	...	...
Leicester Sewage, - - -	72·94	59·22	13·72	5·88	9·68	1·190	1·260	·249	1·554	...	...	14·81	3·95	10·86
Do. do., effluent from 1st tank, - - -	60·90	52·36	8·54	5·04	8·31	·616	1·260	·168	1·428	considerable.	4·36	2·53	1·73	·80
Leicester Sewage, effluent from last tank, - -	55·30	46·90	8·40	3·36	5·54	·385	1·015	·105	1·120	minute.	2·71	5·12	3·89	1·23
Leicester Sewage, effluent from osier bed, - -	59·50	51·24	8·26	3·29	5·43	·343	·910	·091	1·001	do.	5·68	...	...	...
Bolton Sewage, - - - -	39·76	26·60	13·16	5·95	9·79	1·225	1·925	·154	2·079	...	...	12·96	5·56	7·40
Do. do., effluent, -	44·66	35·98	8·68	5·88	9·68	·595	1·505	·133	1·638	considerable.	6·62	1·85	1·11	·74

COMPOSITION OF WATER FROM THE CLYDE, KELVIN, CART, AND LEVEN, &c.

GRAINS PER GALLON.

	In Filtered Water.									Sedimentary Matter.		
	Total Solids.	Saline Matter, &c.	Organic Matter, &c	Chlorine.	Equal to Chloride of Sodium.	Oxygen required to oxidize Org. Mat.	Ammonia.			Total.	Mineral.	Organic.
							Free.	Organic.	Total.			
Clyde at Belvidere, 11th June, 1880, low tide,	14·28	12·04	2·24	·91	1·50	·077	·013	·005	·018	...	...	...
Sewage from Portland Street Sewer, 11th June, 10·30 a.m.,	53·20	39·06	14·14	18·90	31·18	1·456	7·350	·238	7·588	28·01	10·18	17·83
Sewage from Reid Street Sewer, 17th June, 10·45 a.m.	20·02	12·18	7·84	4·20	6·93	1·288	3·850	·224	4·074	47·09	27·03	20·06
Clyde at York Street Ferry, 14th June, low tide,	22·12	18·20	3·92	3·71	6·12	·128	·256	·036	·292	2·09	1·23	·86
Clyde at York Street Ferry, 14th June, high tide,	25·62	21·14	4·48	5·46	9·00	·189	·441	·056	·497	3·88	2·90	·98
Clyde at Govan Ferry, 14th June, low tide,	27·58	23·24	4·34	6·71	11·20	·259	·448	·053	·501	9·06	7·15	1·91
Clyde at Govan Ferry, 14th June, high tide,	34·72	30·10	4·62	9·73	16·04	·252	·427	·053	·480	4·38	3·03	1·35
Clyde at Renfrew Ferry, 15th June, low tide,	30·52	25·20	5·32	7·98	13·16	·248	·413	·052	·465	6·54	4·82	1·72
Clyde at Renfrew Ferry, 15th June, high tide,	192·08	168·56	23·52	87·50	144·37	·210	·322	·049	·371	4·38	2·97	1·41
Clyde at Dumbarton Quay, 16th June, low tide,	859·60	791·00	68·60	443·80	732·27	·105	·164	·029	·193	2·53	1·61	·92
Clyde at Dumbarton Quay, 16th June, high tide,	1601·60	1485·40	116·20	854·00	1409·10	·080	·087	·024	·111	2·34	1·48	·86
Kelvin at Lower West End Park, 12th June, 11 a.m.,	24·50	18·62	5·88	3·22	5·31	·728	1·246	·112	1·358	1·66	1·17	·49
Cart above junction with Gryfe, low tide, 15th June, 0·20 p.m.,	27·16	21·56	5·60	4·55	7·50	·644	·308	·084	·392	4·38	1·92	2·46
Leven above bridge at Dumbarton, low tide, 16th June, 1·15 p.m.	59·08	46·48	12·60	25·62	42·27	·091	·013	·006	·019	·64	·46	·18

IV.—*Opening Address.* By DAVID THOMSON, F.R.I.B.A., President of the Architectural Section.

[Read at the Meeting of the Architectural Section, 8th December, 1880.]

GENTLEMEN,

Again we meet to begin the work of another session, and I have to welcome you to our new premises, where, we trust, the increased comfort will lend a more agreeable aspect to our meetings, and tend to increase our numbers and attendance.

When, at the beginning of last session, I endeavoured to lay before you a sketch of our aims and prospects as a society, I was hopeful that the session then beginning would be one of great interest and usefulness, and that the anticipations of my address would be more than realised in the fruitfulness of the session. The success of last session was, to my mind, marred only by the fewness of our meetings, for the meetings themselves were good, and the papers were of exceptionally high order, and our thanks are justly due to the contributors of those papers, especially to the strangers, who brought before us subjects of great interest, and treated them in such a way as to impart to us all the facts and lessons which an exhaustive examination of the subjects was so well calculated to convey.

Again it is my pleasing duty, this evening, to address you, and I trust that the little I have to say may be considered appropriate to the occasion.

In selecting a subject I had much difficulty, from the abundance of the matters which suggested themselves, but after some hesitation I have elected to ask your attention to a few discursive remarks upon the more public buildings of Glasgow, with special reference to the development of its Classic Architecture.

The subject, in the first place, seemed a suitable one for an opening address; in the second place, it appeared to me that Classic Architecture is likely soon to become the next distraction of that volatile portion of the profession who seek to form and lead the fashion; and, lastly, we have so recently had such a display of classic design in all its types and developments, that we may profitably stop to consider what classic art is in its essentials, and what are the characteristics of classic art, as hitherto practised in this city.

In looking back over the history of Architecture in Glasgow, our attention is arrested by a marked change in the style of buildings which took place at the middle of the last century. Prior to this time the Cathedral, the College, the Merchants' House in the Bridgegate, the Tolbooth at the Cross, and the Tron Church, were the chief architectural objects which adorned the city, and, considering the comparatively small trade and size of the town, as then existing, we think the inhabitants had good reason to be proud of their town and its buildings. About the year 1750 there was a great revival in the building trade. The trade of the town had been largely developed, and a class of wealthy merchants sprung up amongst the citizens, who, by their enterprise and intelligence, laid the foundation of our present greatness and prosperity. The principal merchants then took an active interest in municipal affairs, and lived mostly within the city bounds, so that we find the names of the successive provosts identified with the extension and improvement of the town, and the erection of most of the fine houses which then rose to mark and adorn the newer parts of the city.

With the increase of trade an extension of the streets became necessary, and the magistrates wisely determined on the extension of Argyle Street, and on having it of ample width. This they did by causing the proprietors to keep to the line of houses as then existing, and removing the yards, middens, and other unsightly objects which then encumbered the ground, between the houses and the public roadway. What compensation was given the proprietors is not recorded, but we may suppose that they were left to find their recompense in the increased value of their properties, which the improvement effected. A healthy spirit of enterprise and liberality in things public was abroad, and we find that those who laid off new streets, and the wealthy citizens who then began the erection of new dwellings, did so in a manner which must have seemed very grand and extravagant to the general public.

About this time not only was Argyle Street extended to Hope Street, but Glassford, Virginia, Miller, Queen, and Ingram Streets were opened up and built on.

In 1756 St. Andrew's Church was finished, having occupied 17 years in its erection, and taxing to the utmost the resources of the Corporation. The design is said to be a copy of St. Martin's Church, London, but whether this was intentional or no, we will not now discuss—the resemblance is certainly very close; but all we will at present remark on this point is that, unless the full size details were also copied, the inference from them would be that their designer was no tyro or amateur. What we wish chiefly to note is that the style of Architecture is of a bold rich character, distinctly Roman in its *motif*, large in its parts, robust in its proportions, with strongly marked openings, while the details are all in harmony with these characteristics. The necessity laid upon the architect of including galleries on three sides has in this, as in all churches of this type, marred the unity of the design. The portico being the full height of the side walls, and of one order, does not harmonise well with the division of the side walls, which are in two storeys, and strongly marked by two tiers of windows; and no better illustration can be cited of the injurious effect of fashion upon architecture. Since the days of Palladio and Inigo Jones, Classic Architecture had been praised and practised with an ardent but indiscriminating zeal, without a just appreciation of the principles which pervade and are expressed by the style. Men were learned in all the forms and details of classic work, but overlooked the essential unity of thought which pervaded the works of the ancients from base to apex—controlling every form and moulding every feature in a true and natural relationship.

I do not think it would be just to lay the blame of all the pedantry in Architecture, which resulted from the *rennaisance* in art, to the examples and writings of Palladio, and the other talented men associated with him in the revival of Classic Architecture; for certainly we can detect the same mistaken spirit at work in the writings of Vitruvius. In them we find the same pedantic disquisitions on the parts and proportions of the several orders, with no allusion to the intent and artistic aims sought to be expressed, no indication that the writer had comprehended the unity of design which was stamped on every work of ancient art, and which constitutes their essential quality and cause of excellence. Architecture is the art of constructing buildings so as to perform their several duties in a natural and scientific manner, and combining the whole into one complete structure, shapely and pleasing to the eye, satisfying our sense of order and stability, and, by its enrichments, gratifying our instinct to adorn what we value and possess.

Pedantry in art consists in adopting a style foreign to the native art of the period, and applying the borrowed forms without a just sense of their appropriateness, and irrespective of the altered conditions and requirements of the time.

The demand arose for a new church, and, with a fitting regard for the increased importance of the City, the Town Council determined on the erection of a very grand edifice. They found that in London many handsome city churches had been built by Wren, Gibbs, and others, and thought they could not do better than have a design of a like kind, and in the fashion then prevailing there. We are not disposed to be censorious, yet cannot refrain from expressing regret that they did not adopt a style more indigenous to the country. When we look at the buildings of our old College, with its grand front and graceful tower, and at the steeples at the Cross and the Bridgegate—all that now remains of the Tolbooth and the old Merchants' House—we feel that something might then have been done to develop a style of architecture characteristic of the country, and capable of adaptation to all our requirements in the most natural way, and at the same time favourable to the production of dignity and grandeur of effect.

Virginia Street was formed in 1753, Miller Street in 1771, and Charlotte Street in 1790; and during these years we find that many fine mansions were erected in them by the chief citizens. In all of them we find a similarity of style, and not much variety of design; but there is a certain air of elegance, good workmanship, and finish about them, which reflects credit on the time. The style may be termed Palladian, being similar in arrangement to many of the less ornate designs of that architect; but we seldom find in them his pedantic application of pilasters to decorate the façade, and divide it into panels, in each of which a window is placed, nor do we find pilasters embracing more than one storey in height. Where the orders are introduced, they decorate and emphasise the doorways, and, by the projection of their unbroken entablatures and pediments, porch-like, protect the entrance. We find in these old houses careful adjustment of the relative proportions of openings and wall spaces, which gives pleasing relief and contrast to the elevations; and in the rusticated basements and quoined corners fitting emphasis is found for these parts, which, with the precision and uniformity of arrangements everywhere carried out, lends a certain air of quiet dignity to them, which more ambitious and ornate designs often fail to realise.

The details of the orders, when used, and those of the windows, cornices, pediments—with the urns or vases that usually decked the wallheads—all display a delicacy and refinement which could only be given them by skilful hands; and if the then master-builders were also the architects of these houses, we must credit them with a knowledge, taste, and skill rarely met with among the moderns. At the present time the question has been frequently raised—Why should the designing and the constructing of buildings be separate pursuits, and would not a return to the old practice be conducive to the development of a style in architecture characteristic of the time, and harmonising with all the ideas, progress, and knowledge of the mechanical arts, which so greatly distinguishes this generation?

We do not think such a return will ever be possible, but we very much sympathise with the desire expressed by those critics, when they advocate a return to a style of building which will be regulated by the exigencies of the time, and find direct and truthful expression in the external and internal forms of its architecture, for only then can architecture again become a living art among us.

The first architect whose name is recorded in connection with Glasgow is Sir William Bruce of Kinross, who designed the old Merchants' House and Steeple in the Bridgegate in 1651.

The next on record is James Jeffrey, who in 1780 built old St. Enoch's Church. The only part of his work now remaining is the steeple, and from it we would judge him to have been a man of ability and taste, who practised in the Palladian manner, after the example of Wren.

The Tontine was built in 1781, William Hamilton being the architect, and in this design he displayed much taste in detail and boldness in treatment. The lower storey, now removed or rather converted into shops, was a bold rusticated arcade, the keystones being cut with grotesque masks, their expressive and varied features affording much amusement to the younger portion of the community while they remained—they may be considered as typical of the architectural instincts of the time, and reveal the lack of sculptural ability at the architect's command. The elevation above the arcade still exists, and consists of a series of pilasters embracing two storeys, crowned with a well-proportioned entablature and balustrade, the piers of which are each terminated with richly-carved urns.

If we admit the propriety of pilasters being employed as ornaments, whose function is to divide the front into compartments of a pleasing shape, and to form a setting or frame for the windows, we shall be highly satisfied with this design. The proportions of the openings and intercolumnations are all excellent, and the unity of expression which pervades the whole, regulating and moulding the several parts, and their details, produce a rich, harmonious, and effective elevation, equal to anything in the style we have seen in this country. The question of constructive truthfulness had not then been raised, and no attempt was made to give direct expression to the construction in architectural designs. The architects were then content, as many still remain satisfied, in applying the forms of classic art, and combining or compiling them, with a view to produce a pleasing and pictorial assemblage of forms, with such groupings of the lights and shadows as will fill and satisfy the eye, and form a good subject for an effective drawing.

You will not, I trust, misunderstand me when I say this, or think that I would undervalue those qualities in architectural composition which go to make subjects for effective drawings. What I wish to indicate is, that designs in this manner possess no higher qualities than works of imitative art, and are awanting in those higher qualities of spontaneous development and truthful expression which we find so completely pervading all the works of classic and mediæval times.

In the years 1791, '92, and '96 three important buildings were erected in Glasgow, from designs of the brothers Adams, viz., the Trades' Hall, the Royal Infirmary, and the Assembly Rooms, now the Athenæum. These celebrated and accomplished architects were much employed all over the country, and their works had an influence for good on the taste of the period. Though their designs all have a strong family resemblance, yet in each will be found ample evidence of careful consideration, and such diversity of treatment as to indicate the purpose of the structure and to demonstrate the flexibility of the style. In the Trades' Hall and Athenæum we have two designs for buildings having the like purpose to fulfil—viz., to provide a large hall for public meetings, with suitable accessories—and while both have their entrance in the centre of their front, through a rusticated basement storey, and their entire front above occupied by their public halls, yet the designs are each marked by strong peculiarities of treatment. In the Trades' Hall the centre is but slightly advanced and enriched by a portico of coupled columns, with pediment, marking the centre firmly; but, beyond this, the effect of the design above basement is mainly dependent on the three large Venetian windows, which mark the centre and two wings. There is no attempt to add richness to the front by the introduction of needless pilasters, and the orders are used only to form the upper portico or balcony, and to divide the large Venetian windows, where they appropriately carry the lintels.

We could have wished that more richness had been given to this design by adding moulded decorations to the sides and arches of the large windows, which to us do seem somewhat bold; but, we suppose, the architect did not so much aim at richness of effect as at graceful composition of forms and pleasing contrast of light and shade. We fancy also that, as the elevation was towards the east, they considered the slanting light of the forenoon sun would give length to the shadows, and increase the contrast between the solids and the voids. At anyrate, we find that when they came to design the Athenæum, with its southern front, and less elongated shadows, they adopted bolder projections and more varied forms. In the elevation of this building the orders are introduced as a chief element in the design.

There is more display of decorative treatment here than in the Trades' Hall, but still we find the same thinness of detail and delicacy of proportion prevails over every form in each of the buildings, and is carried into every detail of moulding and sculptured decoration, while about the whole there is an air of culture and refinement which we may well believe characterised these accomplished architects. The Infirmary is of a plainer caste of design, and much injured in aspect by the removal of a large plateau, which existed formerly, and permitted of the upper part of basement only being seen. The basement, as now exposed, looks ridiculously high, and takes away from the prominence due to the first floor a prominence it once possessed. The dome over the centre part of this building was, I think, the first erected in Glasgow; and we may here note that it is not here introduced merely to add a feature to the building, but as a very fit and suitable covering to an operation-room.

These architects were much noted for the graceful proportion they gave to their interiors and the elegant character of their decorations, and in these respects they still reward our study. These decorations, though of Italian *Renaissance* design, are Pompeian in their character and detail, but much of the effect of the interior decorations is lost by the style of painting adopted. Were the clear, primary colours of Pompeian decoration applied, instead of the cold stone or warm drab colours, these halls would still attract more attention and praise.

In 1804 the Hunterian Museum was built, and its erection showed that Glasgow possessed in William Stark a native architect, qualified to design in the purest style of classic art, as then understood, and to bring to its development a mind rich in inventive faculty, bold in conception, and dignified in expression. Mr. Stark's other important works are St. George's Church, built in 1807, and the Asylum, and the Jail, built in 1810.

If we compare these buildings with those of the brothers Adams, we will observe a marked change in the expression. Instead of a chaste, delicate treatment, inclining to weakness, we have a bold dignified expression, full of manly vigour, more in accord with the old Roman manner of building than with the work of the more dainty men of the Italian Renaissance. The Museum was perhaps the most perfect of his works, and displayed a keener sense of the placidity and grace which pervades classic art; the portico was of exquisite proportions, and fittingly marked, sheltered, and adorned the entrance, while the dome crowned the whole edifice, giving to it grace and unity, without lessening the expression of solidity, endurance, and repose, qualities essential in classic art, and more requisite still to give appropriate character to a Museum.

In the design for St. George's Church, Stark attempted to adapt classic forms to the mediæval campanile; and though we think that he, and all others who made the same attempt, failed to carry out in it the true principles of classic art, yet we cannot but applaud the vigour and invention displayed in this design, and the fine gradation of outline and detail which go to form in it one of the best examples of the campanile which this country possesses. To see this design to advantage, we must place ourselves in front, or at some considerable distance above or below it, in Buchanan Street, so that the adjoining buildings, shut out of view the church proper behind it. From either of these points, we shall find that the gradation and grouping of the various parts, from pavement to apex, have all been carefully calculated and boldly expressed, producing a rich and harmonious effect—pictorial in a high degree—the stately breadth and boldness of the forms, and the play of lights and shadows they produce at all times of the day, combine to display effects of great dignity and richness, beside which any purely Gothic spire of like dimensions would seem weak and subdued. While saying all this, we must not fail to notice the disregard of the wholesome restraints of classic art shown in the composition of the lower part of the elevation. where the great three-quarter columns are introduced, forming piers in buttress-fashion, while the entablature is broken round them in true Gothic manner. Above this the orders are all but dispensed with till the lantern part is reached, where they are suitably employed to carry the entablature and dome, which terminates the whole. Here we see the injurious effect of the adoption of a style not the product of the age, and of employing borrowed forms without a rearrangement of the details, to suit the altered conditions of the situation. We could have wished that, instead of using the conventional order, the architect had set himself to design a pier suitable for the purpose, for we do not doubt but that his genius was quite capable of successfully solving the difficulty had the idea presented itself to his mind; but it is very difficult for even the best of men to be much in advance of their time, and the fashion then was to reproduce the forms of classic art with strict fidelity to its proportions and details, the great aim being to make it look as like the old work as possible, and not the outcome of the native mind. The Asylum in Parliamentary Road, now the City Poorhouse, displays in its distribution of parts a bold simplicity of treatment, which gives grace and dignity of effect to a somewhat plain design. There is but little of decorative detail to indicate a style, yet no one hesitates to call it classic, or to admire the outline of its fine dome. In the same year, 1810, Stark also built the Jail; and, while we cannot but approve of the breadth, boldness, and pictorially harmonious rendering of the design, we feel the incongruity produced by placing a portico of such stately proportions in front of a building divided into several floors, with their tiers of openings. To overcome the defect, we find he has given increased depth to the centre part of front, thus deepening the shade under the portico and strengthening its relief, and by this means he has well-nigh succeeded in overcoming the distracting effect of the numerous small openings which he was obliged to introduce.

COMPOSITION OF RAW AND PURIFIED SEWAGE FROM VARIOUS ENGLISH TOWNS.

GRAINS PER GALLON.

	IN SOLUTION.											SEDIMENTARY MATTER.		
	Total Solids.	Saline Matter.	Organic Matter, &c.	Chlorine.	Equal to Chloride of Sodium.	Oxygen required to oxidize Organic Matter.	AMMONIA.			NITRITES.	Free Lime.	Total.	Mineral.	Organic.
							Free.	Organic.	Total.					
Bradford Sewage, - - -	52·64	41·16	11·48	4·13	6·80	·980	·840	·161	1·001	...	...	33·32	12·34	20·98
Do. do., after lime,	124·60	110·60	14·00	4·34	7·15	1·015	·875	·168	1·043	large.	54·58	146·90	114·80	32·10
Do. do., effluent from tank, - - - -	91·28	82·74	8·54	3·64	6·00	1·190	·470	·105	·574	do.	32·06	...	...	...
Bradford Sewage, filtered through "breeze," -	61·04	53·62	7·42	3·64	6·00	1·120	·420	·098	·518	do.	14·76	4·01	4·01	...
Leeds Sewage, - - - -	48·58	39·34	9·24	5·53	9·12	·875	1·085	·182	1·267	...	...	24·37	9·87	14·50
Do. do., mixed with lime, - - - - - - -	42·42	35·42	7·00	6·16	10·15	·840	1·085	·168	1·253	considerable.	2·08	36·84	25·18	11·66
Leeds Sewage, effluent from 6th tank, - - - -	33·32	28·56	4·76	4·76	7·85	·682	·560	·105	·665	large.	1·01	3·95	3·95	...
Leeds Sewage, final effluent,	34·86	29·26	5·60	4·69	7·73	·952	·525	·105	·630	do.	1·01	2·46	2·46	...
Tottenham Sewage, - - -	59·50	47·18	12·32	5·39	8·88	·770	3·010	·322	3·332	...	...	21·10	10·00	11·10
Do. do., effluent,	53·90	43·54	10·36	4·34	7·15	·560	1·400	·154	1·554	small.	4·98	5·55	3·02	2·53
Birmingham Sewage, - -	102·34	80·64	21·70	21·77	35·92	8·512	2·415	·476	2·891	...	...	31·23	16·129	14·94
Do. do., effluent,	55·72	47·18	8·54	12·18	20·09	1·386	1·470	·175	1·645	small.	3·04	·92	·68	·24

Birmingham Sewage, from land irrigation, - -	50·26	38·50	11·76	5·74	9·47	·175	·201	·042	·243	considerable.	10·59	trace.	...	...
Birmingham, River Tame, above Sewage Works,	53·20	45·64	7·56	6·37	10·51	·168	·112	·042	·154	do.	...	14·25	11·11	3·14
Coventry Sewage, - - -	41·30	33·88	7·42	4·83	7·97	·423	1·820	·196	2·016	trace.	...	14·81	6·48	8·33
Do. do., effluent,	45·22	38·08	7·14	3·43	5·66	·294	·805	·098	·903	considerable.	...	2·65	1·42	1·23
Do. do., do., after filtration through land, - - - - - -	44·94	38·78	6·16	3·85	6·35	·178	·647	·035	·682	do.	...	3·58	2·90	·68
Windsor, effluent, - - -	42·42	35·70	6·72	4·41	7·29	·350	1·820	·119	1·939	...	6·12	3·70	2·22	1·48
Do., after land filtration,	42·42	34·16	8·26	4·41	7·29	·375	·980	·105	1·085	considerable.	6·58	...	...	...
Aylesbury Sewage, - - -	49·14	40·74	8·40	4·97	8·19	·700	3·430	·147	3·577	...	...	594·98	456·73	138·25
Do. do., effluent from 1st tank, - - -	48·86	41·58	7·28	4·55	7·50	·385	1·470	·126	1·596	...	...	·98	·46	·52
Aylesbury Sewage, effluent from 2nd tank, - -	48·02	42·42	5·60	3·85	6·35	·245	·980	·126	1·106	...	...	·55	·31	·24
Aylesbury Sewage, final effluent, - - - - -	49·98	44·38	5·60	4·06	6·69	·231	1·190	·112	1·302	...	...	...	...	...
Leicester Sewage, - - -	72·94	59·22	13·72	5·88	9·68	1·190	1·260	·249	1·554	...	...	14·81	3·95	10·86
Do. do., effluent from 1st tank, - - -	60·90	52·36	8·54	5·04	8·31	·616	1·260	·168	1·428	considerable.	4·36	2·53	1·73	·80
Leicester Sewage, effluent from last tank, - -	55·30	46·90	8·40	3·36	5·54	·385	1·015	·105	1·120	minute.	2·71	5·12	3·89	1·23
Leicester Sewage, effluent from osier bed, - -	59·50	51·24	8·26	3·29	5·43	·343	·910	·091	1·001	do.	5·68	...	...	...
Bolton Sewage, - - - -	39·76	26·60	13·16	5·95	9·79	1·225	1·925	·154	2·079	...	...	12·96	5·56	7·40
Do. do., effluent, -	44·66	35·98	8·68	5·88	9·68	·595	1·505	·133	1·638	considerable.	6·62	1·85	1·11	·74

COMPOSITION OF WATER FROM THE CLYDE, KELVIN, CART, AND LEVEN, &c.

Grains per Gallon.

	In Filtered Water.									Sedimentary Matter.		
	Total Solids.	Saline Matter, &c.	Organic Matter, &c	Chlorine.	Equal to Chloride of Sodium.	Oxygen required to oxidize Org. Mat.	Ammonia.			Total.	Mineral.	Organic.
							Free.	Organic.	Total.			
Clyde at Belvidere, 11th June, 1880, low tide, - - - - - - -	14·28	12·04	2·24	·91	1·50	·077	·013	·005	·018	...	...	...
Sewage from Portland Street Sewer, 11th June, 10·30 a.m., - - - -	53·20	39·06	14·14	18·90	31·18	1·456	7·350	·238	7·588	28·01	10·18	17·83
Sewage from Reid Street Sewer, 17th June, 10·45 a.m. - - - - -	20·02	12·18	7·84	4·20	6·93	1·288	3·850	·224	4·074	47·09	27·03	20·06
Clyde at York Street Ferry, 14th June, low tide, - - - - - - -	22·12	18·20	3·92	3·71	6·12	·128	·256	·036	·292	2·09	1·23	·86
Clyde at York Street Ferry, 14th June, high tide, - - - - - -	25·62	21·14	4·48	5·46	9·00	·189	·441	·056	·497	3·88	2·90	·98
Clyde at Govan Ferry, 14th June, low tide, - - - - - - -	27·58	23·24	4·34	6·71	11·20	·259	·448	·053	·501	9·06	7·15	1·91
Clyde at Govan Ferry, 14th June, high tide, - - - - - - -	34·72	30·10	4·62	9·73	16·04	·252	·427	·053	·480	4·38	3·03	1·35
Clyde at Renfrew Ferry, 15th June, low tide, - - - - - - -	30·52	25·20	5·32	7·98	13·16	·248	·413	·052	·465	6·54	4·82	1·72
Clyde at Renfrew Ferry, 15th June, high tide, - - - - - -	192·08	168·56	23·52	87·50	144·37	·210	·322	·049	·371	4·38	2·97	1·41
Clyde at Dumbarton Quay, 16th June, low tide, - - - - - - -	859·60	791·00	68·60	443·80	732·27	·105	·164	·029	·193	2·53	1·61	·92
Clyde at Dumbarton Quay, 16th June, high tide, - - - - - -	1601·60	1485·40	116·20	854·00	1409·10	·080	·087	·024	·111	2·34	1·48	·86
Kelvin at Lower West End Park, 12th June, 11 a.m., - - - - - -	24·50	18·62	5·88	3·22	5·31	·728	1·246	·112	1·358	1·66	1·17	·49
Cart above junction with Gryfe, low tide, 15th June, 0·20 p.m., - -	27·16	21·56	5·60	4·55	7·50	·644	·308	·084	·392	4·38	1·92	2·46
Leven above bridge at Dumbarton, low tide, 16th June, 1·15 p.m. - -	59·08	46·48	12·60	25·62	42·27	·091	·013	·006	·019	·64	·46	·18

IV.—*Opening Address.* By DAVID THOMSON, F.R.I.B.A., President of the Architectural Section.

[Read at the Meeting of the Architectural Section, 8th December, 1880.]

GENTLEMEN,

Again we meet to begin the work of another session, and I have to welcome you to our new premises, where, we trust, the increased comfort will lend a more agreeable aspect to our meetings, and tend to increase our numbers and attendance.

When, at the beginning of last session, I endeavoured to lay before you a sketch of our aims and prospects as a society, I was hopeful that the session then beginning would be one of great interest and usefulness, and that the anticipations of my address would be more than realised in the fruitfulness of the session. The success of last session was, to my mind, marred only by the fewness of our meetings, for the meetings themselves were good, and the papers were of exceptionally high order, and our thanks are justly due to the contributors of those papers, especially to the strangers, who brought before us subjects of great interest, and treated them in such a way as to impart to us all the facts and lessons which an exhaustive examination of the subjects was so well calculated to convey.

Again it is my pleasing duty, this evening, to address you, and I trust that the little I have to say may be considered appropriate to the occasion.

In selecting a subject I had much difficulty, from the abundance of the matters which suggested themselves, but after some hesitation I have elected to ask your attention to a few discursive remarks upon the more public buildings of Glasgow, with special reference to the development of its Classic Architecture.

The subject, in the first place, seemed a suitable one for an opening address; in the second place, it appeared to me that Classic Architecture is likely soon to become the next distraction of that volatile portion of the profession who seek to form and lead the fashion; and, lastly, we have so recently had such a display of classic design in all its types and developments, that we may profitably stop to consider what classic art is in its essentials, and what are the characteristics of classic art, as hitherto practised in this city.

In looking back over the history of Architecture in Glasgow, our attention is arrested by a marked change in the style of buildings which took place at the middle of the last century. Prior to this time the Cathedral, the College, the Merchants' House in the Bridgegate, the Tolbooth at the Cross, and the Tron Church, were the chief architectural objects which adorned the city, and, considering the comparatively small trade and size of the town, as then existing, we think the inhabitants had good reason to be proud of their town and its buildings. About the year 1750 there was a great revival in the building trade. The trade of the town had been largely developed, and a class of wealthy merchants sprung up amongst the citizens, who, by their enterprise and intelligence, laid the foundation of our present greatness and prosperity. The principal merchants then took an active interest in municipal affairs, and lived mostly within the city bounds, so that we find the names of the successive provosts identified with the extension and improvement of the town, and the erection of most of the fine houses which then rose to mark and adorn the newer parts of the city.

With the increase of trade an extension of the streets became necessary, and the magistrates wisely determined on the extension of Argyle Street, and on having it of ample width. This they did by causing the proprietors to keep to the line of houses as then existing, and removing the yards, middens, and other unsightly objects which then encumbered the ground, between the houses and the public roadway. What compensation was given the proprietors is not recorded, but we may suppose that they were left to find their recompense in the increased value of their properties, which the improvement effected. A healthy spirit of enterprise and liberality in things public was abroad, and we find that those who laid off new streets, and the wealthy citizens who then began the erection of new dwellings, did so in a manner which must have seemed very grand and extravagant to the general public.

About this time not only was Argyle Street extended to Hope Street, but Glassford, Virginia, Miller, Queen, and Ingram Streets were opened up and built on.

In 1756 St. Andrew's Church was finished, having occupied 17 years in its erection, and taxing to the utmost the resources of the Corporation. The design is said to be a copy of St. Martin's Church, London, but whether this was intentional or no, we will not now discuss—the resemblance is certainly very close; but all we will at present remark on this point is that, unless the full size details were also copied, the inference from them would be that their designer was no tyro or amateur. What we wish chiefly to note is that the style of Architecture is of a bold rich character, distinctly Roman in its *motif*, large in its parts, robust in its proportions, with strongly marked openings, while the details are all in harmony with these characteristics. The necessity laid upon the architect of including galleries on three sides has in this, as in all churches of this type, marred the unity of the design. The portico being the full height of the side walls, and of one order, does not harmonise well with the division of the side walls, which are in two storeys, and strongly marked by two tiers of windows; and no better illustration can be cited of the injurious effect of fashion upon architecture. Since the days of Palladio and Inigo Jones, Classic Architecture had been praised and practised with an ardent but indiscriminating zeal, without a just appreciation of the principles which pervade and are expressed by the style. Men were learned in all the forms and details of classic work, but overlooked the essential unity of thought which pervaded the works of the ancients from base to apex—controlling every form and moulding every feature in a true and natural relationship.

I do not think it would be just to lay the blame of all the pedantry in Architecture, which resulted from the *rennaisance* in art, to the examples and writings of Palladio, and the other talented men associated with him in the revival of Classic Architecture; for certainly we can detect the same mistaken spirit at work in the writings of Vitruvius. In them we find the same pedantic disquisitions on the parts and proportions of the several orders, with no allusion to the intent and artistic aims sought to be expressed, no indication that the writer had comprehended the unity of design which was stamped on every work of ancient art, and which constitutes their essential quality and cause of excellence. Architecture is the art of constructing buildings so as to perform their several duties in a natural and scientific manner, and combining the whole into one complete structure, shapely and pleasing to the eye, satisfying our sense of order and stability, and, by its enrichments, gratifying our instinct to adorn what we value and possess.

Pedantry in art consists in adopting a style foreign to the native art of the period, and applying the borrowed forms without a just sense of their appropriateness, and irrespective of the altered conditions and requirements of the time.

The demand arose for a new church, and, with a fitting regard for the increased importance of the City, the Town Council determined on the erection of a very grand edifice. They found that in London many handsome city churches had been built by Wren, Gibbs, and others, and thought they could not do better than have a design of a like kind, and in the fashion then prevailing there. We are not disposed to be censorious, yet cannot refrain from expressing regret that they did not adopt a style more indigenous to the country. When we look at the buildings of our old College, with its grand front and graceful tower, and at the steeples at the Cross and the Bridgegate—all that now remains of the Tolbooth and the old Merchants' House—we feel that something might then have been done to develop a style of architecture characteristic of the country, and capable of adaptation to all our requirements in the most natural way, and at the same time favourable to the production of dignity and grandeur of effect.

Virginia Street was formed in 1753, Miller Street in 1771, and Charlotte Street in 1790; and during these years we find that many fine mansions were erected in them by the chief citizens. In all of them we find a similarity of style, and not much variety of design; but there is a certain air of elegance, good workmanship, and finish about them, which reflects credit on the time. The style may be termed Palladian, being similar in arrangement to many of the less ornate designs of that architect; but we seldom find in them his pedantic application of pilasters to decorate the façade, and divide it into panels, in each of which a window is placed, nor do we find pilasters embracing more than one storey in height. Where the orders are introduced, they decorate and emphasise the doorways, and, by the projection of their unbroken entablatures and pediments, porch-like, protect the entrance. We find in these old houses careful adjustment of the relative proportions of openings and wall spaces, which gives pleasing relief and contrast to the elevations; and in the rusticated basements and quoined corners fitting emphasis is found for these parts, which, with the precision and uniformity of arrangements everywhere carried out, lends a certain air of quiet dignity to them, which more ambitious and ornate designs often fail to realise.

The details of the orders, when used, and those of the windows, cornices, pediments—with the urns or vases that usually decked the wallheads—all display a delicacy and refinement which could only be given them by skilful hands; and if the then master-builders were also the architects of these houses, we must credit them with a knowledge, taste, and skill rarely met with among the moderns. At the present time the question has been frequently raised—Why should the designing and the constructing of buildings be separate pursuits, and would not a return to the old practice be conducive to the development of a style in architecture characteristic of the time, and harmonising with all the ideas, progress, and knowledge of the mechanical arts, which so greatly distinguishes this generation?

We do not think such a return will ever be possible, but we very much sympathise with the desire expressed by those critics, when they advocate a return to a style of building which will be regulated by the exigencies of the time, and find direct and truthful expression in the external and internal forms of its architecture, for only then can architecture again become a living art among us.

The first architect whose name is recorded in connection with Glasgow is Sir William Bruce of Kinross, who designed the old Merchants' House and Steeple in the Bridgegate in 1651.

The next on record is James Jeffrey, who in 1780 built old St. Enoch's Church. The only part of his work now remaining is the steeple, and from it we would judge him to have been a man of ability and taste, who practised in the Palladian manner, after the example of Wren.

The Tontine was built in 1781, William Hamilton being the architect, and in this design he displayed much taste in detail and boldness in treatment. The lower storey, now removed or rather converted into shops, was a bold rusticated arcade, the keystones being cut with grotesque masks, their expressive and varied features affording much amusement to the younger portion of the community while they remained—they may be considered as typical of the architectural instincts of the time, and reveal the lack of sculptural ability at the architect's command. The elevation above the arcade still exists, and consists of a series of pilasters embracing two storeys, crowned with a well-proportioned entablature and balustrade, the piers of which are each terminated with richly-carved urns.

If we admit the propriety of pilasters being employed as ornaments, whose function is to divide the front into compartments of a pleasing shape, and to form a setting or frame for the windows, we shall be highly satisfied with this design. The proportions of the openings and intercolumnations are all excellent, and the unity of expression which pervades the whole, regulating and moulding the several parts, and their details, produce a rich, harmonious, and effective elevation, equal to anything in the style we have seen in this country. The question of constructive truthfulness had not then been raised, and no attempt was made to give direct expression to the construction in architectural designs. The architects were then content, as many still remain satisfied, in applying the forms of classic art, and combining or compiling them, with a view to produce a pleasing and pictorial assemblage of forms, with such groupings of the lights and shadows as will fill and satisfy the eye, and form a good subject for an effective drawing.

You will not, I trust, misunderstand me when I say this, or think that I would undervalue those qualities in architectural composition which go to make subjects for effective drawings. What I wish to indicate is, that designs in this manner possess no higher qualities than works of imitative art, and are awanting in those higher qualities of spontaneous development and truthful expression which we find so completely pervading all the works of classic and mediæval times.

In the years 1791, '92, and '96 three important buildings were erected in Glasgow, from designs of the brothers Adams, viz., the Trades' Hall, the Royal Infirmary, and the Assembly Rooms, now the Athenæum. These celebrated and accomplished architects were much employed all over the country, and their works had an influence for good on the taste of the period. Though their designs all have a strong family resemblance, yet in each will be found ample evidence of careful consideration, and such diversity of treatment as to indicate the purpose of the structure and to demonstrate the flexibility of the style. In the Trades' Hall and Athenæum we have two designs for buildings having the like purpose to fulfil—viz., to provide a large hall for public meetings, with suitable accessories—and while both have their entrance in the centre of their front, through a rusticated basement storey, and their entire front above occupied by their public halls, yet the designs are each marked by strong peculiarities of treatment. In the Trades' Hall the centre is but slightly advanced and enriched by a portico of coupled columns, with pediment, marking the centre firmly; but, beyond this, the effect of the design above basement is mainly dependent on the three large Venetian windows, which mark the centre and two wings. There is no attempt to add richness to the front by the introduction of needless pilasters, and the orders are used only to form the upper portico or balcony, and to divide the large Venetian windows, where they appropriately carry the lintels.

We could have wished that more richness had been given to this design by adding moulded decorations to the sides and arches of the large windows, which to us do seem somewhat bold; but, we suppose, the architect did not so much aim at richness of effect as at graceful composition of forms and pleasing contrast of light and shade. We fancy also that, as the elevation was towards the east, they considered the slanting light of the forenoon sun would give length to the shadows, and increase the contrast between the solids and the voids. At anyrate, we find that when they came to design the Athenæum, with its southern front, and less elongated shadows, they adopted bolder projections and more varied forms. In the elevation of this building the orders are introduced as a chief element in the design.

There is more display of decorative treatment here than in the Trades' Hall, but still we find the same thinness of detail and delicacy of proportion prevails over every form in each of the buildings, and is carried into every detail of moulding and sculptured decoration, while about the whole there is an air of culture and refinement which we may well believe characterised these accomplished architects. The Infirmary is of a plainer caste of design, and much injured in aspect by the removal of a large plateau, which existed formerly, and permitted of the upper part of basement only being seen. The basement, as now exposed, looks ridiculously high, and takes away from the prominence due to the first floor a prominence it once possessed. The dome over the centre part of this building was, I think, the first erected in Glasgow; and we may here note that it is not here introduced merely to add a feature to the building, but as a very fit and suitable covering to an operation-room.

These architects were much noted for the graceful proportion they gave to their interiors and the elegant character of their decorations, and in these respects they still reward our study. These decorations, though of Italian *Renaissance* design, are Pompeian in their character and detail, but much of the effect of the interior decorations is lost by the style of painting adopted. Were the clear, primary colours of Pompeian decoration applied, instead of the cold stone or warm drab colours, these halls would still attract more attention and praise.

In 1804 the Hunterian Museum was built, and its erection showed that Glasgow possessed in William Stark a native architect, qualified to design in the purest style of classic art, as then understood, and to bring to its development a mind rich in inventive faculty, bold in conception, and dignified in expression. Mr. Stark's other important works are St. George's Church, built in 1807, and the Asylum, and the Jail, built in 1810.

If we compare these buildings with those of the brothers Adams, we will observe a marked change in the expression. Instead of a chaste, delicate treatment, inclining to weakness, we have a bold dignified expression, full of manly vigour, more in accord with the old Roman manner of building than with the work of the more dainty men of the Italian Renaissance. The Museum was perhaps the most perfect of his works, and displayed a keener sense of the placidity and grace which pervades classic art; the portico was of exquisite proportions, and fittingly marked, sheltered, and adorned the entrance, while the dome crowned the whole edifice, giving to it grace and unity, without lessening the expression of solidity, endurance, and repose, qualities essential in classic art, and more requisite still to give appropriate character to a Museum.

In the design for St. George's Church, Stark attempted to adapt classic forms to the mediæval campanile; and though we think that he, and all others who made the same attempt, failed to carry out in it the true principles of classic art, yet we cannot but applaud the vigour and invention displayed in this design, and the fine gradation of outline and detail which go to form in it one of the best examples of the campanile which this country possesses. To see this design to advantage, we must place ourselves in front, or at some considerable distance above or below it, in Buchanan Street, so that the adjoining buildings, shut out of view the church proper behind it. From either of these points, we shall find that the gradation and grouping of the various parts, from pavement to apex, have all been carefully calculated and boldly expressed, producing a rich and harmonious effect—pictorial in a high degree—the stately breadth and boldness of the forms, and the play of lights and shadows they produce at all times of the day, combine to display effects of great dignity and richness, beside which any purely Gothic spire of like dimensions would seem weak and subdued. While saying all this, we must not fail to notice the disregard of the wholesome restraints of classic art shown in the composition of the lower part of the elevation. where the great three-quarter columns are introduced, forming piers in buttress-fashion, while the entablature is broken round them in true Gothic manner. Above this the orders are all but dispensed with till the lantern part is reached, where they are suitably employed to carry the entablature and dome, which terminates the whole. Here we see the injurious effect of the adoption of a style not the product of the age, and of employing borrowed forms without a rearrangement of the details, to suit the altered conditions of the situation. We could have wished that, instead of using the conventional order, the architect had set himself to design a pier suitable for the purpose, for we do not doubt but that his genius was quite capable of successfully solving the difficulty had the idea presented itself to his mind; but it is very difficult for even the best of men to be much in advance of their time, and the fashion then was to reproduce the forms of classic art with strict fidelity to its proportions and details, the great aim being to make it look as like the old work as possible, and not the outcome of the native mind. The Asylum in Parliamentary Road, now the City Poorhouse, displays in its distribution of parts a bold simplicity of treatment, which gives grace and dignity of effect to a somewhat plain design. There is but little of decorative detail to indicate a style, yet no one hesitates to call it classic, or to admire the outline of its fine dome. In the same year, 1810, Stark also built the Jail; and, while we cannot but approve of the breadth, boldness, and pictorially harmonious rendering of the design, we feel the incongruity produced by placing a portico of such stately proportions in front of a building divided into several floors, with their tiers of openings. To overcome the defect, we find he has given increased depth to the centre part of front, thus deepening the shade under the portico and strengthening its relief, and by this means he has well-nigh succeeded in overcoming the distracting effect of the numerous small openings which he was obliged to introduce.

We think, also, he did well to employ the Grecian Doric for his portico, as by it he was enabled to give to his design an expression of simple dignity and calm severity most suitable for the entrance to a court-house and a prison. In the wings he has introduced the *antæ* as pilasters, which correspond in height with the columns of the portico, but fail in repeating anything of the columnar character—looking poor and unmeaning to a degree rarely reached in any pilastered imitations of Roman work. Notwithstanding such defects—resulting from the employment of forms, the purposes of which had not been fully apprehended—we are of opinion that his works evince, by the boldness and general harmony of their outlines and distribution, that he was a true master-builder—not merely a designer of architectural decorations, though he had also much power as a decorator, and combined the forms and details of his buildings so as to produce powerful and appropriate effects, with rich groupings of light and shade; and if we compare his buildings with those of the brothers Adams, we shall not fail to observe that there is in them something quite different in quality from the dilettante spirit so strongly pervading those other works.

In 1805, when the Hunterian Museum was fresh from the hands of Stark, David Hamilton was intrusted with the design for Hutchesons' Hospital, Ingram Street, and it is very interesting to mark the great change which came over the spirit of his design, after this, his first important work. Of the details of Hamilton's early training I have no information, but judging from this design I would imagine that he had studied much the works of the brothers Adams, and the Palladian school, then so high in favour. There is no attempt in this design to give to it the impress of the bold Roman type, which so strongly characterizes his subsequent works, but he, like the Adams', freely accepts the primary division of the buildings into two storeys as the needful accommodation demanded, and treats it in simple, truthful, and effective manner. The details are remarkable for their weakness in outline, and want of distinctness, being in this respect much less effective than those of the Athenæum. The lower storey is channelled or rusticated, but without solidity of effect, and wants all the boldness and repose which a rusticated basement is so well calculated to produce, and none knew better than he, in after years, how to design and where to employ this style of treatment. In the arrangements of the upper parts of the front we see indications of the future excellence of the man. Here we have a colonnade of Corinthian pillars in the centre, between two wings of solid construction, the plainness of which contrast well with the open colonnade and pierced wall behind, each giving emphasis to the other. Appropriate niches are placed in each of the wings, and are filled with statues of the generous brothers; but so well adjusted are the parts that the solidity of the wings is not marred, and the figures are well relieved. The statues are in unison with the architecture, neither being the work of greatly skilled and experienced hands; but, for all that, they compare favourably with a recent combination of similar features in Renfield Street, where two statues, in like situation, do not seem so happy in their place. In the design of the spire which adorns this building we have again an evidence of his constructive and artistic ability, and of his fertility in design—its outline and proportions are all fine, and harmonize well with the structure below—that is to say, with the front elevation—for the treatment of the elevation to John Street is feeble in the extreme. Here we have thin pilasters dividing the wall into compartments, with a window in each, the details of each looking poorer from the excess of blank wall by which they are surrounded. The thinness of the pilasters, which attract attention on the side, have a contrary effect in the wings, where, from their flatness, they do not disturb the solidity and breadth; but we regret their use at all, and could wish that pilasters had never been invented. Some architects, when they employ the classic style, seem to find them indispensable, and would resent our condemnation of their use, and declare that they were suitable and necessary; but we have but to point to the practice of the Greeks in proof of our assertion that they can be dispensed with, and we think the architecture gains in point and decision by their omission. When in Glassford Street the other day I was pleased to observe that one of our members had, in similar circumstances, adopted the Greek idea with marked effect, and I am glad to be able so easily to point to a local instance of this better mode of treatment.

In the City Bank, Virginia Street, so lately removed, we have a design by Hamilton, in which similar elements are combined—viz., a rusticated basement, with a colonnade occupying the upper portion of the front, but the details here are all in his most vigorous and perfect manner, and the effect, for so plain a building, was a model of excellence and worthy of study by all who would adopt classic art to our modern requirements. Here we have no attempt to gain effect by embracing two floors in the height of an order, no broken entablatures, but all is conceived in true spirit—the structural and internal divisions being directly indicated and suitably expressed without affectation, but with a grace, simplicity, and vigour, satisfying both mind and eye. We cannot but regret that, as is inevitable, the works of this architect are one by one being obliterated, and trust some careful drawings of them are being preserved.

Of the numerous works yet remaining by this accomplished architect, the chief one is, undoubtedly, the Royal Exchange, and after it may be reckoned the Western Club, the British Linen Bank, and, till very recently, the Union Bank; each one of them well worthy of careful study, for in each there is evidence of the working of a clear and powerful intellect, decision of character, great knowledge of resources, and the possibilities of combinations, with full, rich imagination and freedom of handling. In each the pictorial qualities are fully developed, whilst over and through all the hand of the master-builder is strongly expressed; no feeling of dilettanteism or servile imitation is decernable in any of their features or details, though the orthodox orders are freely used; but so thoroughly is the feeling for the breadth and fulness of Roman work embodied in each, that they have all the impress of an original work. We have said Roman, not Renaissance, believing that the architect was now more under the influence of the old Roman art than he had formerly been when designing Hutchesons' Hospital. The Hospital was erected in 1805, and the Exchange was not begun till 1828, and it would be interesting to trace by his works the gradual development of his mind during this long interval had we a detailed record of the works done by him during that time. This I have not been able to do, and, for the present, must content myself by remarking that in the interval he had thoroughly matured his powers, and developed a breadth of manner and mastery of combination and detail, which ennobled his works and placed them in the first rank, where they continue to challenge comparison with the best works of British art. The designing of the Exchange was a work of much difficulty, owing to the necessity laid upon the architect of incorporating a large portion of the old mansion, and including in his design a number of offices and other apartments not part of the Exchange proper. This building is so familiar to us all that I need not enter into a description of its parts, but content myself with a few observations upon their arrangements as examples of his skill in design.

To preserve the unity of effect produced by the stately portico in front, note the manner in which he has introduced the colonnades on the north and south, where they mark the portion devoted to the Exchange proper, and, by repeating the features of the portico, add richness, grace, and unity to the whole, keeping up the stately, bold character of the front, without monotony, but rather adding variety and piquancy to the whole. In the treatment of the sides immediately west of the portico he has also displayed great readiness of adaptation. Here he had to show two floors, with their windows, exponents of important rooms in each, and he has employed unfluted pilasters to divide the front laterally, and to bring these pilasters into strong relief, so that they might partake largely of the character, and maintain the effect of those other parts, he has filled the spaces between with windows, having strongly-detailed architraves, cornices, pediments, and belt courses, the boldness and multiplicity of their shadows producing a mass of dark colour which, by contrast, throw the pilasters into stronger relief. The capitals of these pilasters, it may also be here noted, are not a repetition of the columns, as is usual, but specially designed, and of less height. The portico, though but an assemblage of Corinthian columns, borrowed from the works of the Romans, yet possesses a grace and dignity of proportions which might be very easily missed by one compiling from the book without the matured judgment and just perception of those qualities of combination which go to form classic art. By the great projection he has given the portico, he well-nigh obliterates the incongruous effect of a double tier of openings in the wall behind. The shade is so deep that the doors and windows above them are barely seen, and the details of these, in marked contrast with those in side walls, between the pilasters, are subdued and quiet. The Belfry, which surmounts the front, is very finely proportioned and enriched, and harmonises so completely with the whole structure below that we feel as if the whole forms and details were the original outcome of one mind, and not a combination of features, the elements of a past phase of art. It is in this quality, we think, Hamilton's works so greatly excel. They seem to be less the result of a careful application of borrowed forms than the product of his own thought, his handling is always so masterful, and his individuality so marked. Compare any of his works with the old Bank of Scotland, the Royal Bank, or the Custom-House, all of which were built about the time the Exchange was erected, and, while you will find in all of these good proportions and careful detail, you will see but little of the character of the designers. They might all have been built by one man, though a separate architect was engaged on each, but they show so little departure from the stereotype examples that they fail to interest us much. The Exchange has been more fortunate in its surroundings than most public buildings in this country, and the effect of it is much enhanced by the buildings which form the Square, the breadth, simplicity, and regularity of their distribution forming a harmonious background to it—the plainness of the one giving greater effect to the rich variety of the other.

The British Linen Bank and Western Club were built in 1840, the Union Bank in 1842, and the City of Glasgow Bank in the following year. These were busy years with Hamilton—his powers were in full vigour and constant exercise on many important works all over the country. All of them will repay careful examination, but for the present I will limit my remarks to the British Linen Bank and the Western Club. In these we have good examples of his fertility in design; they are in different styles, and each quite distinct from that of his other works we have referred to. In each of these buildings he had to deal with similar requirements, both of them are three storeys high, with numerous apartments in each floor, and, while something of a residential character was to be given to each, they were yet required to have an aspect of dignity and importance indicative of a public building. The British Linen may be thought to partake more of a palatial character than is suitable for a bank, and the principal entrance wants in importance, being less marked than we could wish, but the whole design is conceived in a rich, stately manner, and the detail is all full of clear, bold outlines, more delicate than those of his other buildings, and with more inclination to florid treatment in its parts. The ground floor is rusticated, and the upper floors have their windows framed, as it were, between broad, upright bands, which mark the distribution of the elevation and enrich its light and shade, serving to produce the same pictorial effect for which pilasters are usually employed. The main cornice and balustrade, which crowns the elevation, are finely conceived and adjusted, and, though many similar cornices have since been executed, I know of none equal to it for graceful proportion and precision of contrast. One curious bit of detail in this building has caused me trouble to account for it, being so false in constructive idea and so unlike the work of a master-builder, and that is—a boldly carved band-course, placed upon the cornice of the ground floor windows, and sustaining the balcony of windows above, forming the most unsuitable foundation upon which to rest a balustrade. It must have been an overlook. The art of carving had not made much progress in those days, and this we find was the weak part in all the building of the time. While the orthodox Corinthian capital was fairly well cut and the acanthus scroll and patera were carefully carved, after the models left us by the Romans, there was but little ability or knowledge displayed in the designs, and still less delicacy in the execution of the ornaments. In this respect the architecture of the present day displays a marked and pleasing contrast to that of Hamilton's time, and an interesting subject to bring before this Society would be the development of ornamental art in Glasgow, from the days of the Tontine faces till now, when such exquisite sculptured decorations adorn our streets.

The design of the Club is of a more bold and concentrated aspect than that of the Bank; in it the opportunity afforded by the large apartments on the ground floor is taken full advantage of, and expressed in the large grouped windows which front Buchanan Street. The portico is also finely conceived, and made to harmonise with the broad, massive elevation. Being only one storey high, a less able man would have found difficulty in retaining the breadth and dignity of the front, but we here see how the architect attains the desired effect—by making the columns square and unfluted, by placing them close together, and imparting to its details like qualities of breadth and boldness. The grand effect produced in this building is dependent on the largeness of its parts, the grouping of its prominent features, and the great preponderance of the wall spaces. The openings are all enriched with bold details, which the ample breadth of wall around them throws into still stronger relief. The main cornice is, perhaps, the greatest in projection and most marked in light and shade that this country possesses, and has always been the subject of much laudatory criticism, as being conceived in true unison with the powerful outlines and bold relief which pervades the whole design. It is a most rare thing to find one's self at a loss to trace the design of a modern building to its prototype in the past, but such is the case with reference to this one. When we look at the Exchange, the Union, or City Bank, we are strongly reminded of the works of the Roman builders; and when we look at the British Linen Bank we can recall something of the Renaissance palaces of Rome and Florence, though greatly changed; but here, beyond a general impression of the massive grandeur of these Italian palaces, there is little we can recognise of old device, but much that may be claimed as original. In one of the architectural journals I lately read an article on classic architecture as practised in Scotland, and was pleased to find that the writer freely accorded to our architects the merit of designing classic work with more breadth and vigour than is attained by our English brethren, and he accounted for the fact by our greater familiarity with building in stone, and the abundance of that fine material found so ready to our hand. There is no doubt but that the abundance of our stone, and the universal practice of building in that material, has had much to do in the creation of our taste for classic architecture, for without these it would not have been possible in this poor country to carry out so many great and noble buildings in that style; and without the continuous exercise of the architectural faculty, working through this essential element, it would have been impossible for our architects to have attained such mastery in detail and combination of classic forms. But, whilst we acknowledge all this, we think that the influence of a few great men who have from time to time risen in our midst, has also greatly assisted in forming the public taste, and in keeping the weaker brethren up to a higher level than has been realised in the south. The works of Stark and Hamilton, of Glasgow, and Playfair, of Edinburgh, have undoubtedly largely influenced and moulded our architectural perceptions, and guided the youthful studies of the generation which followed them, and, we trust, many of the examples they have left to us may long continue to be objects of careful study to generations yet to come.

Up to the present time the architecture of our City has been mainly of a classic type, and few seemed surprised when it became known that the Town Council had determined that the new municipal buildings should be in the classic style; though not assured in my own mind, that another style would not have lent itself more freely to the requirements of our time, I do not much regret the exclusive nature of the decision, and trust that, notwithstanding all the troubles yet to come, the result may yet be to have our good City adorned with a noble pile of buildings, in which classic art shall be displayed in all the grace of dignity, elegance, and refinement, of which the style is so pre-eminently qualified to become both the recipient and exponent.

A careful survey of the designs submitted in the competition has left on my mind the impression that the ideal qualities of classic art are not much appreciated by the present generation, and that pictorial groupings, florid elaboration, and exuberance of detail, are more in harmony with the taste of the time. Since the erection of our County Buildings, no such opportunity had arisen to stimulate and call forth the energies of native architects, and I felt disappointed on finding that I could select few from among them partaking of those fine qualities of breadth, placidity, clear rendering, and careful adjustment of light and shade which so strongly characterise the design of the County Buildings.

The prominent features in this design are the portico and podium of the south front, and the colonnade on the west side. The portico indicates the entrance front of the portion allotted to county business, whilst the colonnade denotes the portion occupied by the Merchants' Hall, in these respects resembling the arrangement we noticed in the Exchange, but with increased effect, by reason of the greater contrast afforded by the plainer parts of the elevations which intervene, and the deep, level shadow produced by the balcony at level of the first floor. The three floors are shown clearly—the two upper ones being included in one order—and the dexterity with which the difficulty is met all but overcomes the feeling of the contrariety of purpose thus conjoined. Behind the portico the openings are carefully subdued, the upper windows being omitted, and the mass and beauty of the podium, with the deep shade of the portico above, is increased in force by their contrast, fill the eye, rendering the wings, with their double tier of openings, less observable.

In the colonnade, again, the columns are so closely set that when seen in conjunction with the south front the windows between them are entirely hid from view. This was the second occasion in which really fine sculptured decoration was employed in our buildings, and their intrinsic excellence and harmonious treatment are a constant source of enjoyment, and have borne fruit in the increased desire we see to-day for such fitting adornment of our buildings.

My remarks have lengthened beyond my anticipations, and I feel it is time they were brought to a close, but I would not wish to do so without a few words of deserved commendation on the works of three architects, who in their day did much to give grace and character to our streets.

In John Street U.P. Church we have a characteristic and fine design of the late Mr. Rochead, full of bold relief and vigorous treatment, rich in details, and well balanced in pictorial effect, free from affectation of manner, and pervaded with a unison of feeling for force and richness of effect—a character he gave to all his works. We may not approve of the manner in which the inter-columnations of the upper part are filled entirely with glass, but we cannot but applaud the vigour and excellence displayed in the design of the lower portion, and when we look from it to the rusticated basement of the Hospital building we have proof of the great advancement in the power of design which marks the interval of years. In the Unitarian Church we have another good example of classic design by the same architect. In it there is less tendency to undue elaboration of detail and forcible effects than is usual in his works. Besides these, we have several other buildings of classic design which adorn our streets, and exemplify the vigour and elasticity of his abilities as an architect.

In the Faculty of Procurators' Library we have a fine example of Renaissance-classic design after the Venetian type. This is a work of the late Charles Wilson—a man held in high esteem by the public and his professional brethren for his abilities as an architect, his genial manners and disposition, and his high regard for the honour of the profession. An examination of the arrangements and details of this design will reveal the careful consideration by which its every feature has been modulated. All the forms, both of the voids and wall spaces, are clear in outline and of good proportions in themselves, well balanced and contrasted, no preconceived effect being marred by the intrusion of unnecessary objects, but all the elements and details made harmonious in character, and reflecting in some measure a clear intellect, matured judgment, and refined sense of beauty in architectural adornment. This design, like those of the Hutchesons' Hospital, Trades' Hall, Athenæum, and City Bank, consists of a rusticated basement, the upper part being occupied by a colonnade. In this case the columns are coupled and attached to the wall, the openings between being arched with coved and panelled ingoings, enriched with carving, the ends of Library being suitably expressed by large Venetian windows. Another work of this architect deserving special reference is Elmbank Academy. The style is Italian, after the manner practised in Florence—the distinctive features in this style being the absence or very subordinate use of the orders—the elements of design consisting of the doors and windows, with their embellishments, the level band-courses marking the division of the floors, the bold console cornices which crown the walls, and the profusion of rustication employed to mark the angles, or to add force to the basements. Since it has become the High School, the four great rusticated piers which mark the principal entrance have had placed on them the statues which they were originally designed to carry, and this added grace lightens up the whole elevation, which previously was wanting somewhat in expression. The grace, simplicity, and stately repose embodied in this design are in the architect's best manner, and display those qualities of his mind more clearly than some of his subsequent works, though in all of them the same qualities largely predominate. The chief among his other classic works in Glasgow are the Free Church College and Church, the Queen's Rooms, and the Royal Bank Buildings in Buchanan Street, all of which it would be instructive and interesting to go over in detail did time permit.

In the works of the late Mr. Alexander Thomson we have a fine series of designs of a character so unique and excellent as to excite our wonder at the fertility of his inventive faculties and our admiration at the beauty, richness, and vigour of his handling. In all of them he set himself to adapt the principles of Greek art to modern requirements, without any pedantic borrowing of their features. Indeed, it is quite surprising how seldom we find in his works the orders reproduced, with their details, strictly conforming to the ancient remains. He more frequently originates some form of column and capital, designed to meet the special requirements he had to deal with, or to conform to the character of the impression he wished the building to convey; but where he has used the orders they are appropriately placed, finely proportioned and detailed, with carefully adjusted relief, the wall space behind being kept subdued in tone, with no disturbing objects in it to mar the repose and quiet dignity of the design. The multiplicity and variety of the details and forms he introduced into his works, and the singular grace and unity of effect he maintained throughout, are deserving of our most careful consideration, showing as they do that to adopt a style does not necessarily imply that only those marked features and peculiarities of detail and combinations which are found in the original works are to be reproduced, but that new forms and details may freely be employed, provided we have skill enough to maintain the spirit and essential qualities of the style. Of none of his designs can it be said that they are very like the old work, a term of praise we often hear applied to the works of our best men of mediæval proclivities; but, whilst they differ from the works of the Greeks as distinctly as the nature of our requirements do from theirs, they agree with them in the adaptation of forms to the purposes they subserve—the grouping of the parts into forms in which the horizontal lines predominate, the clear marking of the voids, the precision of their distribution, and the graceful adjustment of light and shade, with strength and placidity as a general expression. Only by the adoption of such principles as these can building be raised into a fine art.

His churches in St. Vincent Street and Caledonia Road are in his best manner, while the various warehouses and other street buildings by his hand are all marked by the same elegance and refinement of detail, and display the abundance of his resources in design, and his power of impressing on them his own ideal perception of art.

From all I have said, the conclusion may be drawn that hitherto Glasgow has been well served by its architects, and I will conclude with the expression of my confident expectation that in the future the architects of Glasgow will maintain the honourable position they have thus inherited; and I trust that the labours of this section may become an efficient instrument in promoting the advancement of architecture and the arts therewith incorporated.

V.—*Some Observations on the Colouring Matter of Jelly-fishes.*

By Professor M'KENDRICK.

[Read before the Society, December 15th, 1880.]

WE are all more or less familiar with the splendid colours of some of the Medusæ, or Jelly-fishes, found in our seas, but I am not aware that anyone has made any investigation into the properties of the colouring matter. In the month of September last I spent some time at the Scottish Zoological Station, then located on the shores of the Cromarty Firth, just opposite Cromarty, and by the kindness of my friends, Professor Ewart of Aberdeen, and Mr. G. J. Romanes—whose researches on the movements of Jelly-fishes are well known—I had an opportunity of making some observations.

The specimens examined were the beautiful blue *Cyanea*, *Chrysaora*, distinguished by the patches of brown round the tentacles and the margin of the umbrella and in the long arms, and *Aurelia*, with the crescentic masses of colour round the ovaries.

In the first place, by microscopical examination, I ascertained that the colouring matter is not uniformly distributed throughout the protoplasm of these creatures, but that it exists in the form of little irregularly-shaped particles in the protoplasm of minute cell-like bodies. The particles or granules were about the 1-30,000th of an inch in diameter; in the case of *Chrysaora* they were of a yellowish colour, while in *Cyanea* they had a faint tinge of blue. The protoplasm surrounding these granules was colourless. The observations were made with a $\frac{1}{15}$ objective of Ross adapted to a Hartnack microscope, with No. 3 objective and the draw tube out—magnifying power about 1200 diameter.

I then attempted to extract the colouring matter. Cutting off the coloured fringes of a large specimen of *Chrysaora*, I placed portions in (*a*) strong caustic potash, (*b*) absolute alcohol, (*c*) sulphuric ether, and (*d*) in sea water. In the course of about an hour, the portions in strong caustic potash were disintegrated and broken up into shreds of a dark brown colour, whilst the fluid remained colourless. No effect was produced by absolute alcohol or by ether; but the colour in the fragments immersed in sea water diffused out to a considerable extent in the course of twenty-four hours. The fluid then was of a dark brown colour. Pressure caused no separation of the colouring matter.

I then boiled portions in sea water and in ordinary fresh water, and found that boiling caused the colouring matter to diffuse out quickly. On filtering the fluid, it was found to be acid, and of a dark brown colour. This colour at once disappeared on the addition of strong sulphuric acid. Strong nitric and strong hydrochloric acids produced the same effects, but not so quickly as sulphuric acid. Strong caustic potash caused a reddish-brown precipitate, but, as the fluid consisted of sea-water, at least a portion of this precipitate must have consisted of the hydrated oxides of lime and magnesia in the water. On comparing the effect of adding a solution of caustic potash of the same strength to the same bulk of sea-water and of infusion of Jelly-fish, the precipitate was decidedly bulkier in the latter case.

As regards *Cyanea* and *Aurelia*, I found that neither pressure, boiling, nor any of the fluids at my command—such as the mineral acids, the alkalies, alcohol, or ether—dissolved out the colouring matter. The only way of obtaining it was to allow fragments of the Jelly-fish to macerate in sea-water for about 36 hours. Then the fluid became of a sky-blue colour when *Cyanea* was used, and slightly pink in the case of *Aurelia*. My next object was to separate the colouring stuff from this fluid. It could not be extracted by alcohol or ether, or by any solution at my disposal; but I ascertained that the fluid thus obtained was slightly acid, and it occurred to me that the colouring matter might be thrown down by an alkali. Experiment showed this to be the case. On adding ammonia to any coloured infusion of Jelly-fish, a copious precipitate falls which carries with it the whole of the colouring matter. After filtration the fluid is quite colourless, and the colouring matter remains on the filter. Again, the precipitate is readily re-dissolved by acid, and the colouring matter again passes into a soluble state. It is soluble, therefore, in an acid medium, but insoluble in an alkaline or neutral medium. Now, fresh Jelly-fishes, so far as I could make out, were quite neutral to test paper. I could not find any alkaline reaction. But in the living Jelly-fish we can scarcely suppose that the colouring matter exists in the granular form simply because the medium is alkaline or neutral; all we can state is that the medium is neutral, and the probability is that the coloured stuff is formed in the protoplasm of certain cells, just as pigment is formed in the cells of the epidermis of many animals. After the death of the Jelly-fish, however, the body becomes slightly acid, the protoplasm disintegrates, and the colouring matter diffuses out. It is interesting to point out here the analogy to what happens in the case of a muscle. During life, a muscle is slightly alkaline or neutral; after death, when rigor sets in, it becomes acid.

I have not had an opportunity of examining the chemical nature of the colouring matter. That is a subject suitable for the chemist, and out of my province; but I have pointed out a method by which the colour-stuff can be obtained.

It was a matter of interest to examine the colouring matter with the spectroscope. By means of this instrument, chlorophyll has been discovered in some of the *Protozoa*, in some *Porifera*, in *Hydra viridis*, in the Sea Anemone, *Anthea cereus*, and even in a species of Crustacean. Various absorption spectra have been studied in certain Cœlenterata, Echinodermata, Worms, Insects, and Molluscs; whilst in the Vertebrata the colouring matter of the blood has received much attention.*

I found that infusion of *Chrysaora* gave no distinct absorption bands; but the violet, blue, and a portion of the green were absorbed, the other colours being slightly reduced in intensity. On concentrating the fluid, the red, yellow, and what remained of the green became very dim; but no bands existed.

With *Cyanea*, however, the case was different. An infusion of this creature containing the colouring matter gave two distinct absorption bands, one in the red and the other in the orange. I also observed these bands very distinctly by placing an uninjured small specimen in a flat glass dish below the microscope. The only blue colouring matters met with in the animal kingdom that I find any record of is a blue colouring matter obtained from *Stentor cœruleus*, described by Lankester,† which gives two absorption bands, nearly the same in position as those observed in *Cyanea*, and a blue matter, called *Hœmocyanine*, found in the blood of the Octopus, which, however, has no definite absorption bands.

VI.—REPORT BY R. F. MUIRHEAD, B.SC., DELEGATE FROM THE GLASGOW PHILOSOPHICAL SOCIETY TO THE BRITISH ASSOCIATION, 1880.

[Read before the Society, December 15th, 1880.]

BY the kindness of Dr. Fergus, M.R.C.S., Eng., and then President of the Glasgow Philosophical Society, I was appointed delegate to the last meeting of the British Association for the Advancement of Science, to represent him, as President of this Society.

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* See Gamgee's "Physiological Chemistry," vol. i., p. 305.

† E. Ray Lankester on Blue Stentorin, the colouring matter of *Stentor cœruleus*.—*Quarterly Journal of Microscopical Science*, April, 1873.

On the 31st of August I attended a Conference of Delegates from Scientific Societies, convened by Mr. John Hopkinson, F.L.S., F.G.S., Hon. Secretary of the Hertfordshire Natural History Society and Field Club. Mr. Hopkinson stated that his object in calling the meeting was to see whether something useful could not be done by delegates from Scientific Societies to the British Association. Up to the present nothing had been attempted. With the view of attaining his object, Mr. Hopkinson had, at the Sheffield meeting of the British Association, proposed to the Council that, in addition to the President or his delegate, the Secretary of any Scientific Society of the United Kingdom, publishing printed Proceedings, should be admitted to represent his Society in the General Committee. This, he thought, would render it possible for conferences of delegates to be held, at which matters relating to Scientific Societies might be discussed—a thing which would be impossible were the secretaries absent. The Council of the Association had received this proposal favourably, and altered the rules to give it effect.

Mr. Hopkinson then mentioned several matters—such as interchange of ideas as to the management of societies, exchange of Proceedings, and combination for the purpose of systematising scientific work—which he thought might advantageously occupy the attention of a yearly meeting of delegates.

After some discussion, it was decided unanimously to adopt the following resolution, proposed by Mr. David Grieve, F.R.S.E., President of the Royal Physical Society of Edinburgh, and seconded by Prof. G. A. Lebour, M.A., F.G.S., of Newcastle:—

> "That this conference recommends that at future meetings of "the British Association it is desirable that delegates from the "various scientific societies should meet, with the view of pro-"moting the best interests of the Association, and of the several "societies represented."

It was also resolved that a meeting of delegates be held next year, during the meeting of the British Association at York.

To Mr. Hopkinson and Mr. H. Geo. Fordham, F.G.S., delegate from the London Geologists' Association, were entrusted powers as a committee of the delegates, to bring before the different scientific societies of the United Kingdom the amended rule regarding the admission of secretaries as delegates, and to draw their attention to the advantages that might accrue from conferences of delegates at the meetings of the British Association.

I have much pleasure in submitting this Report to the Society, in the hope that it will recognise the advantages of Mr. Hopkinson's proposal.

No other matter called for my action as delegate from this Society.

VII.—*An Ether Percolator, for Estimation of Fats, &c., in Organic Substances.* By DONALD MACPHAIL, M.B., C.M.

[Read before the Society, January 5th, 1881.]

To thoroughly extract fatty or other matters soluble in ether from organic substances by ordinary washing and maceration is a very tedious and unsatisfactory proceeding, as a great many successive washings are required to make the process complete, and if heat is required, the use of a flame is very apt to cause an explosion and conflagration. Owing to the great trouble entailed by the ordinary methods, experienced during investigations in the chemical composition of diseased bone at present being prosecuted in the Pathological Laboratory at the Western Infirmary, and the large quantity of ether wasted, we found it necessary to devise some apparatus to economise both time and material. Such an apparatus was made, and, after many experiments and much modification, has assumed the form here shown. (See Plate.) A description and drawing of the percolator were published in the *Journal of Anatomy and Physiology* for October, 1880 (vol. xv.). The one shown here is, however, more simple in construction, and more easily made. It is constructed of glass tubing of various sizes, with pierced india-rubber corks and grey india-rubber tubing for the couplings, &c. It can be made by any one, at the cost of a few shillings.

The apparatus has proved very useful. It works safely and easily, and, once set in action, will work for hours without further attention, keeping a continuous stream of pure ether passing through the substance under treatment, and that with almost no loss of ether from evaporation: in fact, could the joints be made perfectly tight, there would be no loss of ether at all. In the machine in use at the Western Infirmary the chamber in which the substance under treatment is contained fills with ether and empties itself about ten times in fifteen minutes. As the chamber receives about 8 cc. of ether each time, it follows that the ether passes through at the rate of 320 cc. per hour, or 7 litres 680 cc. (over 1½ gallons) in twenty-four hours: and this it does with a loss of only about 40 cc. out of the 60 put in when the machine is set going—a loss really inconsiderable when we consider the amount of work the small quantity of ether is made to do. The necessary heat is got by the use of hot water from the taps with which laboratories are usually fitted up, so that should an escape of ether vapour occur from any defects in the couplings or other joints, there is no risk of conflagration from contact with a flame.

First, to explain the construction of the apparatus, and then the manner in which it works.

A long piece of glass tubing (A), about ¼ inch in diameter, is bent into a U shape, so as to have one limb 30 inches long, the other 24 inches, and the cross piece 3½ inches. Upon each limb there is fitted a jacket (B^1, B^2) of ¾-inch glass tubing, closed at both ends by two-holed india-rubber corks, through which the U-tube passes, each jacket allowing the tube to project about 2 inches from its lower end. Through the corks at the upper end of the machine are passed the ends of a T-tube (C), the stem of which is turned upwards, and then bent over and carried to the sink. This tube acts as overflow pipe to the two cylinders. Through the corks at the lower ends of the cylinders are passed T tubes (X and Y), which, by an arrangement of clips, act as inlet pipes when the apparatus is working, or as outflow pipes, as may be necessary. The T tube at X is connected with a hot water tap, that at Y with a cold water tap. The end of the long limb of the U tube, which projects through the cork at the bottom of cylinder B^1, is bent so as to pass through the india-rubber cork of the flask (D), and the end of the other limb passes through the cork (also india-rubber) of the test-tube (E). This cork has a short piece of glass tubing passing through it (Z), which can be closed with a cork. Blown on, or coupled to, the bottom of the test-tube there is a syphon (F) of fine glass tubing (⅛-inch), the upper bend of which reaches to a little above two-thirds of the height of the test-tube, the end passing through the cork of the flask, and reaching almost to the bottom of that vessel. The flask is set in a tin canister (G), which has a half-inch metal inlet pipe soldered in near the bottom, and a similar overflow pipe near the top. The inlet pipe is connected with a hot water tap. The whole apparatus is fastened to an upright board, with a folding shelf, on which the canister rests. The apparatus thus constructed is ready for use.

The ether is put into the flask, between two and three ounces being generally enough to keep the apparatus working for eighteen or twenty-four hours. The substance to be washed is put into the test-tube, a small pellet of purified cotton-wool wrapped in muslin being first put in to act as a filter. The test-tube, syphon, and flask, are then adjusted to the rest of the apparatus, the canister slipped over the flask from beneath, and the shelf put in below the canister. The hot water, which must have a temperature between 60° and 70° C., is allowed to flow through the canister, and the ether soon boils. At the same time the hot water is allowed to flow into the cylinder B^1, the clip X being closed, but that at Y being open, and the small tube at Z also open. The hot water will flow up the long cylinder and down the short one, escaping at Y, quickly heating the whole apparatus, so that all the air is driven out by the ether vapour. As soon as the air has been expelled, which is seen by ether vapour escaping by the open tube at Z, that tube is corked, the clip at Y closed, and the cold water turned on into the cylinder at B^2, which drives the hot water out of that cylinder, bringing the long overflow pipe into operation. Thus set going, the apparatus is ready to work for hours without further attention.

The ether, vapourized in the flask, is carried up the heated tube within the long cylinder, and is condensed in the tube within the short or cold cylinder. It flows down and collects in the test tube till it reaches the level of the upper bend of the syphon, when it at once runs over into the flask again, carrying with it the dissolved matter, and this process is repeated without intermission as long as the machine is kept working, or sufficient ether remains to fill the test tube up to the required level. This level can, of course, be altered at will by lengthening or shortening the syphon.

In this way, all the substances that are soluble in ether are thoroughly dissolved and washed out by being constantly acted on by fresh quantities of pure ether, and as the process goes on they gradually accumulate in the flask.

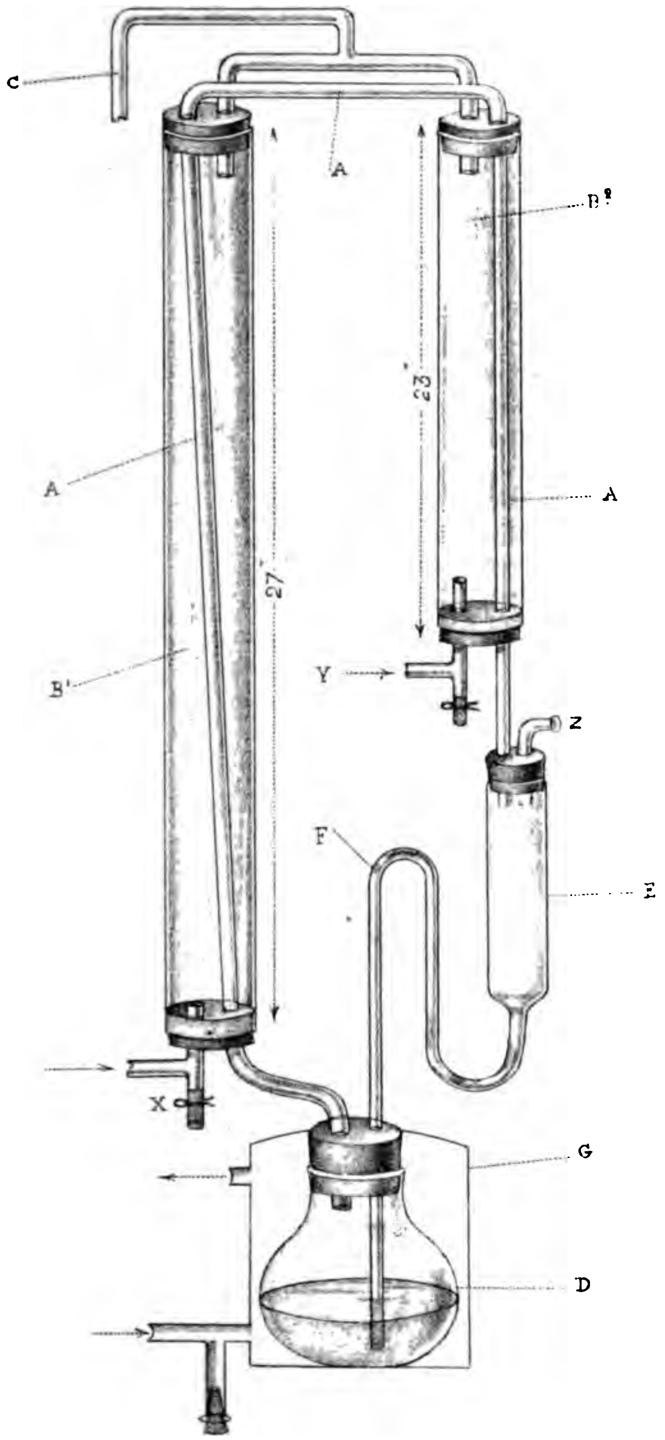
To stop the machine, turn off the hot water, and open the clip at X and turn off the hot water, at the same time opening the tube at Z to allow air to enter as the ether vapour in the tube is condensed. As the hot water in the long cylinder runs out at X, the cold water from the other cylinder follows it across the T-tube at the top, and rapidly cools the whole apparatus.

When it is wished to boil the substance to be analysed in the ether, they may be put together into the flask and a simple tube substituted for the test-tube and syphon, so that the vapour of the boiling ether is condensed and flows back directly.

This apparatus will doubtless ensure more accurate results in analyses of organic tissues than can be obtained by the methods hitherto in use in physiological or pathological laboratories. By increasing its size it would be available for much larger quantities, and should be found useful for making etherial extracts in pharmaceutical and other chemical operations.

DESCRIPTION OF PLATE.

A.—Long U-tube, within which the ether vapour is conveyed and condensed.
B^1.—Hot water jacket, surrounding A.
B^2.—Cold water do.
C.—Common overflow pipe from B^1 and B^2.
D.—Flask containing ether.
E.—Chamber containing the substance to be washed with ether.
F.—Syphon conveying ether from E to D.
G.—Tin jacket with inlet and overflow pipe, within which the flask D is heated.
X.—T-tube, the horizontal limb of which acts as inlet pipe, and the vertical (when open) as outflow pipe for B^1.
Y.—Do. for B^2.
Z.—Tube through cork of E, through which air is expelled or admitted. (This opening is in reality the safety valve of the machine.)


C
A
B²
A
23"
27"
A
B'
Y
Z
F
E
X
G
D

VIII.—*On a Method of foretelling the Quality of Wheat Harvests by the Wheat Blossoms.* Translated from the French of M. Bidard, of Rouen (Secretary of the Societé Centrale d'Agriculture de la Seine-Inferieure), by F. J. ROWAN.—Communicated by ST. J. V. DAY, C.E., F.R.S.E., &c.

[Read before the Society, January 5th, 1881.]

WE spend nearly two-thirds of our human existence in probing the hidden mysteries of the future. Curiosity, ambition, unrest—all the motives of the human heart tend to our penetrating the secret of that "to-morrow" which, according to the poet, we cannot take from God. With some, this perpetual aspiration towards the unknown is little more than a protest against the miseries of the present; but the prescience of the future may be considered the "philosopher's stone" of industry, of speculation, and of commerce. To predict, even some days in advance, a political event of importance, is enough to enrich one by speculation in the Funds; the knowledge of coming atmospheric changes renders weighty services to agriculture; it is also for the seafaring man a certain pledge of safety. In brief, uncertain chances in commercial operations would be sensibly lessened if we could foresee, even approximately, the scarcity or abundance of the commodity in which we do business.

In certain of these commodities—the cereals, for example—this divination would be of advantage not only to a few, for in the case which we have just cited it would represent an interest, both general and social, of the first importance.

In the actual state of our knowledge, the value of a harvest of wheat cannot be appraised before the threshing—that is to say, before the end of August at the soonest. By this time the markets of producing countries which are more southern than we are are already invaded by business; and when there is scarcity in them a rise takes place, which renders transactions heavier than they would have been if the demand had been met two months sooner, or at the time when the produce was lower than it is at the moment of pressure.

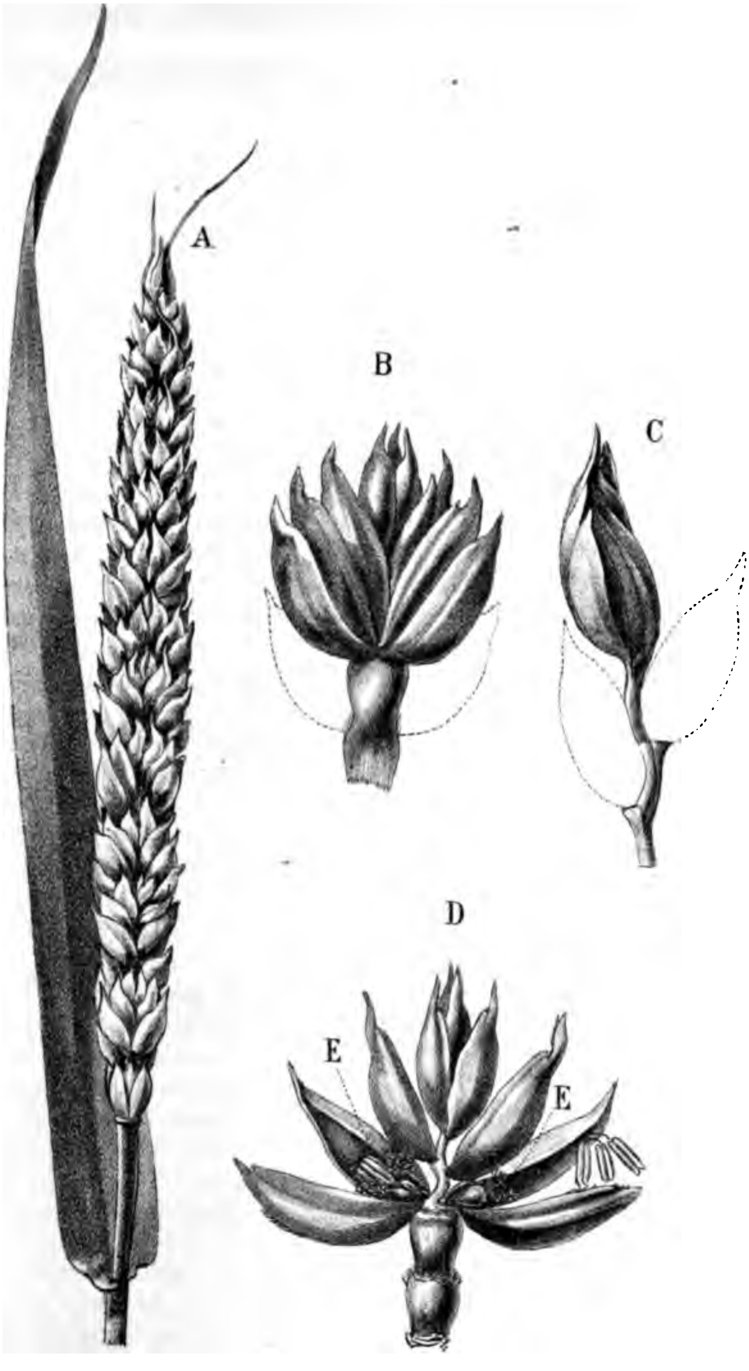
After long and patient study of the flower (or blossom) of wheat, I am convinced that it is possible to predict a good or bad harvest by the 15th to 30th June, and it is this conviction that I here essay to convey to you.

The complete vegetation of a wheat plant divides itself into four phases or periods which are very distinct, viz.:—1st, the germination; 2nd, the foliaceous vegetation; 3rd, the blossoming and fertilizing (fecundation); and 4th, the ripening which causes the milky juice of the grain to pass into the state of gluten and starch. Each of these phases requires a fixed amount of heat, which is, however, different in each case.

1. Germination is content with little, 5 or 6 degrees Cent. (= 41 to 42·8 Fahr.) suffice for the grain confined in the earth, to develop the herbaceous shoot containing already the elements of the future ear, which can easily be distinguished with a microscope of 80 diameters.

2. This commencement of the ear is then protected against the cold which is experienced in January, February, March, and April, by a sheath of five superposed leaves. The development of these embryonic leaves, what I have called the foliaceous vegetation, the production of stubble and of its knobs, demands a temperature of 15 or 16 degrees (59 or 60·8 Fahr.); it may, however, be satisfied with a little less.

3. We come now to the truly critical phase, that of the fertilizing. In an article published in the journal *L'Illustration*, of 3rd June, 1866, and more recently and completely in the *Journal d'Agriculture pratique*, I have minutely described the admirable organs by means of which it proceeds in a nutritive plant par excellence, and the various phenomena through which it passes. I only refer to it here to establish the fact, that a certain elevation of temperature is indispensable to the lateral opening of the anthers to an extent sufficient for the absorption of the pollen, which the act of fertilizing consumes. This temperature is 22 degrees (71·6 Fahr.). The rise or the fall of the thermometer is equally decisive when the blossoming of the wheat has reached its culminating point. If it falls below 22 degrees, especially if rain comes unexpectedly, not only do the anthers not open, but many of them do not even come out of the envelope represented at E in figure D, in the Plate. A large number of the small spikes or ears, nearly all, if these atmospheric conditions are prolonged, miscarry and remain sterile—all hope of a harvest is lost. If 22 degrees are reached, on the contrary, fertilizing takes place under normal conditions, and does not require for its realization more than 15 or 20 minutes, according to a botanist of Rouen—*one minute* only, according to my view, is general, and then I do not fear to affirm



ar of Wheat **B.** Spikelet (or Small Ear) solid, as it exists in the Ear. C. Spikelet, Side
-**D. Spikelet,** open as a *fan, shewing on the left* Side at E the flower (or blossom) be
fertilizing. *and on the right side at E the flower after* fertilizing.

that the crop may be considered as already safe, although bad weather may come during the period of ripening.

Thus, in observing the thermometric variations at the time of blossoming, and in following attentively the phenomena; in studying the ear (A); in examining one by one each of its spikelets (B and C); and in being assured of the quantity of these which have been fertilized, we have the means of foretelling, if not exactly, at least very approximately, what will be the future produce of the harvest, and this by the 15th to 30th June, as I have already said. The advantages which would accrue to agriculture and commerce by putting in practice a system so easy of application, are much too evident to need descanting upon.

An examination of what took place in 1862 may serve to illustrate these rules which I would establish. Germination was effected under good conditions; the wheat was not sufficiently advanced to cause it to suffer by the rigorous cold which marked the commencement of the winter. The cold in January, February, and March, held back the foliaceous vegetation, which in May reached its full activity. In June, at the critical time, the temperature kept at 10 to 12 degrees (50 to 53·7 Fahr.), and, the organs having arrived at their full development, the situation was one of extreme anxiety for several days. But on the 15th a temperature of 15 degrees (59 Fahr.) was reached, and on the 20th the thermometer registered 24 degrees (75·2 Fahr.). The work of fertilizing could not be carried on under better conditions, so that, although subsequently one could note thermometric oscillations which went as low as 14 degrees, yet the harvest was not less rich than we had desired it would be.

Further, we are not the first to attribute to the blossoming of the wheat an influence of which the cultivators did not know well enough how to take note, for the Chinese, who are pre-eminently a people of observation, have given attention to it much before us.

In his curious "Voyage en Chine" (tom. ii., p. 354), Father Huc relates what follows of a conversation which he had on this subject with one of his neophytes. He says, "He told us that the numerous kinds (species) of wheat arrange themselves in two classes, viz.:—(1) that of which the blossoming always and invariably commences during the night; and (2) that which cannot blossom but in daytime. The choice of soils and the time of sowing ought to vary according to the kind of wheat, and he maintained that to fail to recognise these two classes, and to conform to the regulations prescribed for each of them, was to be greatly exposed to bad harvests."

This is, moreover, not the first time it has been proved that in the strife between the Chinese and us on the battle-field of agriculture, the advantage is not ours.

IX.—*On the Action of Anæsthetics.* By Professor M'Kendrick.

[Read before the Society, 5th January, 1881.]

At the meeting of the British Medical Association in Manchester, in 1877, a committee was appointed to investigate the action of anæsthetics. The committee originally consisted of John G. M'Kendrick, M.D., Professor of Physiology in the University of Glasgow; Joseph Coats, M.D., Pathologist and Lecturer on Pathology, Western Infirmary, Glasgow; and William Ramsay, Ph.D., Assistant to the Professor of Chemistry in the University of Glasgow. Dr. Ramsay retired from the committee on his appointment to the Chair of Chemistry in University College, Bristol, when David Newman, M.B., Pathological Chemist, Western Infirmary, Glasgow, became a member of the committee.

The various agents used were administered to animals, and the effects on the heart and on respiration were observed. The committee used a method on frogs by which the effect on the heart could be observed; and, in the case of some of the agents, performed the experiment on rabbits and dogs, using artificial respiration, and exposing the heart. It may here be remarked that, in these experiments, the anæsthetics were given intentionally in large doses, because, if any substitute for chloroform is to be found, it must be one which may safely be given in exceptionally full doses. The following substances were administered:—

1. *Benzine* (C_6H_6) was used with the frog. Its effects were nearly as slow as those of ether, and it produced struggling; weakening of the heart was apparent, but not so great as with chloroform.

2. *Acetone* (C_3H_6O) produced only slight anæsthesia in the frog, even after prolonged administration.

3. *Pyrrol* (C_4H_5N) produced anæsthesia in frogs with considerable less rapidity than chloroform, but great excitement

and muscular spasm took place before complete anæsthesia. Administered to three young rabbits subcutaneously, it produced convulsive movements, chiefly of the jaws and fore-paws. Anæsthesia in these rabbits was doubtful.

4. *Bichloride of Methylene* (so called, but, as it has not a definite and constant boiling point, it is obviously a mixture.—Reputed formula, CH_2Cl_2). With frogs, it was found that the heart became quickly affected, and soon stopped. With rabbits, respiration rapidly deteriorated and stopped, while the heart was still beating. In an experiment with artificial respiration and exposure of the heart, the heart was weakened and soon stopped, but not so rapidly as with chloroform. As in the case of chloroform, the right ventricle became enormously distended—the first sign of paralysis being the commencement of this distension.

5. *Amylene* (C_5H_{10}) was administered to rabbits both by cloth and subcutaneously. No anæsthetic effect was produced.

6. *Butyl Chloride* (C_4H_9Cl) administered to rabbits affected respiration, but not very rapidly. In experiments with exposure of the heart, the cardiac pulsations became weaker, and ceased altogether after some time. In one experiment it was noted that, almost immediately after complete anæsthesia, the respirations became shallow, and soon stopped.

7. *Ethene Dichloride* (formerly named ethylene dichloride, or Dutch liquid, $C_2H_4Cl_2$) produced convulsive movements of both extremities, continuing up to death. There was no anæsthesia up to the commencement of the convulsions.

8. *Methyl Chloride* (CH_3Cl), which boils at the ordinary temperature, was obtained in alcoholic solution in a sealed tube, and allowed to boil off into a funnel, into which the muzzle of a rabbit was inserted. After somewhat prolonged use, there was not any abolition of reflex action, and the animal almost immediately recovered. The only effect was slight drowsiness.

9. *Ethyl Chloride* (C_2H_5Cl, boiling at 12° Cent. $= 53{\cdot}6°$ Fahr.), administered to rabbits in the same way as the above, produced rapid anæsthesia; but in one case the respirations soon stopped, and in another, when air was admitted more freely, general convulsions occurred.

10. *Nitrous Ethyl Ether* ($C_2H_5NO_2$) produced great excitement and convulsions, almost immediately followed by cessation of respiration.

It was apparent that the above substances all presented disadvantages which rendered them unsuitable for general use as anæsthetics. There remained two agents, the actions of which were more promising. These were isobutyl chloride and ethidene dichloride.

11. *Isobutyl Chloride* (C_5H_9Cl). A. *Experiments on Frogs:* When it was administered under a glass jar, complete anæsthesia occurred in about five minutes. The heart was then exposed, and it was observed for thirty-five minutes, during which period its contractions were perfectly vigorous. B. *Experiments on Rabbits:* When it was administered with a cloth, anæsthesia was produced in three to five minutes. It was continued after anæsthesia for nearly half-an-hour, without any interference with respiration. C. *Experiments on Dogs:* It was administered on cloth; anæsthesia was produced in four minutes. It was continued for half-an-hour, and respiration was unaffected, except slight occasional stertor.

12. *Ethidene Dichloride* ($C_2H_4Cl_2$, an isomeride of ethene dichloride produced from aldehyde). A. *Experiments on Frogs:* Administered as before. The exposed heart continued beating slowly but regularly throughout the experiment, which lasted in one case twenty minutes, and in another twenty-six minutes. Anæsthesia was produced in four or five minutes. B. *Experiments on Rabbits:* It was given on cloth, as usual. Anæsthesia was produced within four minutes. On one occasion respiration stopped, but soon recommenced. In experiments with artificial respiration and exposure of heart, the cardiac contractions continued vigorous throughout, the observation being continued for forty minutes from the first administration. C. *Experiments on Dogs:* It was administered on cloth. Anæsthesia was produced in two or three minutes. In one case anæsthesia was accompanied with some excitement, manifested by squealing; the animal was a young puppy. In another case, a large dog was kept fully anæsthetized for half-an-hour, without the slightest failure of respiration or heart. The anæsthesia in this case was very rapid, and the administration was intentionally pushed with successive doses at short intervals, as evaporation took place. The recovery was rapid, and the animal manifested remarkably good spirits. D. Two experiments were made on dogs, in which the heart was exposed, artificial respiration being kept up. No failure of the heart's action was observed, although the air passing into the lungs was saturated with the vapour of the substance. There was complete

anæsthesia. On quickly removing the bottle containing ethidene dichloride, and substituting chloroform, the right side of the heart began almost immediately to become distended, and to be dark in colour, and the activity of the heart rapidly failed. The contrast between the effects of the two substances on the heart was most striking. Practically, a dog will live for a lengthened period in a state of complete anæsthesia under the influence of ethidene dichloride, while it will die in a short time when chloroform is used.

It is worthy of observation that two substances, butyl chloride and isobutyl chloride, which have the same chemical formula, exhibit such different actions. The same contrast is seen in the actions of ethene dichloride and ethidene dichloride, which are also isomeric. The first of these produced severe convulsions, while the second promises to be an excellent anæsthetic without any convulsive effects.

It was now necessary to test the effects of the two substances whose results seemed promising, and of any others of similar value, on the higher animals and on man.

Dr. M'Kendrick then described the methods of observation, and illustrated his remarks by showing diagrams, tracings, and apparatus. The complete report of the committee having appeared in the *British Medical Journal* of December 18th, 1880, No. 1043, it is necessary here to give only the general results arrived at by the committee. These were as follows:—

A.—CLINICAL.

I. The dose (administered on a towel) is greater with ethidene than chloroform; but the time necessary to anæsthetise the patient is longer with the latter than the former agent.

II. The number of cases of sickness and vomiting is about the same with the two agents, but the duration is considerably protracted in the case of chloroform; the occurrence of these symptoms have no relation to the length of time the patient has been under, or reference to the quantity of anæsthetic administered in a given time.

III. With both agents, the pulse respiration ratio is considerably altered in a certain number of cases, the pulse falling as the respirations increase in frequency. With chloroform, this change is not only much more marked, but its occurrence is also more frequent than with ethidene; the proportion, in our experience, being nine of the former to two of the latter. There is also a greater tendency in cases of chloroform to retardation of the heart's movements, and to dicrotism.

B.—PHYSIOLOGICAL.

I. The effect of anæsthesia with chloroform is to increase the amount of carbonic acid exhaled in a given time. The results of our investigations, in connection with the effects of anæsthetics on the gases of the blood, are not sufficiently reliable to permit us giving results.

II. Both chloroform and ethidene, administered to animals, have a decided effect in reducing the blood-pressure; while ether has no appreciable effect of this kind.

III. Chloroform reduces the pressure much more rapidly, and to a greater extent, than ethidene.

IV. Chloroform has sometimes an unexpected and apparently capricious effect on the heart's action, the pressure being reduced with great rapidity almost to *nil*, while the pulsations are greatly retarded, or even stopped. The occurrence of these sudden and unlooked-for effects on the heart's action seems to be a source of serious danger to life—all the more that, in two instances, they occurred more than a minute after chloroform had ceased to be administered, and after the recovery of the blood-pressure.

V. Ethidene reduces the blood-pressure by regular gradations, and not, so far as observed, by these sudden and unexpected depressions.

VI. Chloroform may cause death in dogs either by primarily paralysing the heart or the respiration. The variations in this respect seem to depend to some extent on individual peculiarities of the animals; in some the cardiac centres are more readily affected, in others the respiratory. But peculiarities in the condition of the same animal very probably have some effect in determining the vulnerability of these two centres respectively; and they may both fail simultaneously.

VII. In most cases respiration stops before the heart's action; but there was one instance in which respiration continued while the heart had stopped, and only failed a considerable number of seconds after the heart had resumed.

VIII. The use of artificial respiration was very effective in restoring animals in danger of dying from the influence of chloroform.

In one instance its prolonged use produced recovery even when the heart had ceased beating for a considerable time.

IX. Under the use of ethidene, there was on no single occasion an absolute cessation either of the heart's action or of respiration, although they were sometimes very much reduced. It can, therefore, be said that, though not free from danger on the side of the heart and respiration, this agent is in a very high degree safer than chloroform.

X. In regard to the effect of anæsthetics upon the pulmonary circulation; as in the experiments on the effects of the anæsthetics upon the blood-pressure, it may be stated that chloroform produces the most immediate effect, ether the least, whilst ethidene occupies an intermediate position.

XI. The quantity of air, and the length of time required to restore the circulation in the lung, are in an inverse ratio to the amount of anæsthetic vapour, and time necessary to stop it.

XII. The changes produced in the lung are the same in all; the only difference being in the rapidity of their occurrence.

XIII. The anæsthetics produce the following changes in the lungs—(1) retardation and ultimate stoppage of the circulation in the lung: first in the capillaries, then in the arterioles, and subsequently in the larger vessels; (2) the epithelium-cells of the meshes and their nuclei are no longer apparent; (3) the capillaries contract slightly, and their walls become less distinct, or even disappear from view, and the enclosed corpuscles may become more or less disintegrated.

XIV. The effect of ether and ethidene upon the heart, after artificial respiration for seven and five minutes respectively, is simply to produce a retardation of the impulses—ethidene having the most marked effect. Chloroform not only produces a retardation of the pulse, but the ventricular contractions are delayed and slightly separated from the auricular, and an auricular contraction may immediately follow the ventricular. The auricular contractions frequently occur without any corresponding ventricular movements.

C.—PRACTICAL.

The conclusions to be drawn from the above observations are these—

I. It is not only necessary to watch the effect of the anæsthetic upon the pulse, but it is also requisite to have regard to the respiration. We must not only take into account the danger of sudden stoppage of the respiration, but must also remember that, in the event of abnormal increase of respiratory movements, it may become essential, for the safety of the patient, to temporarily discontinue the administration.

II. Owing to the tendency of chloroform and ethidine—particularly chloroform—to reduce the blood-pressure suddenly, not only during the administration of these agents, *but also after they have been stopped for some little time* (a source of serious danger), it is necessary for the person who has charge of the administration of the drug to be on the look-out for symptoms of this occurrence, both during the time the agent is being given, and for some time after the patient has recovered from its more evident effects.

III. The danger of death, from stoppage of the respiratory functions, must be borne in mind in every case in which anæsthetics are given; but, of perhaps greater importance is the danger from interference with the proper action of the heart—particularly when it is remembered that, by artificial means, we can combat the former contingency. It might even be advisable, in certain cases, to introduce a tracheal-tube by the mouth—so as to enable us to force air into the lungs by means similar to those adopted in experiments with animals; or, in circumstances where such a procedure was impracticable, tracheotomy might be performed, with the same object in view. Artificial respiration should be continued even though all evidence of cardiac action has ceased.

IV. As regards comparative danger, the three anæsthetics may be arranged in the following order: chloroform, ethidene, ether; and the ease with which the vital functions can be restored may be conversely stated, thus: the circulation is more easily re-established when its cessation is due to ether than to ethidene; and when the result of ethidene, than when chloroform has been used. The advantages which chloroform possesses over ether—in being more agreeable to the patient and more rapid in its action, in the complete insensibility produced by it, and the absence of excitement or movements during the operation—are more than counterbalanced by its additional dangers.

V. The chief dangers are: (1) sudden stoppage of the heart; (2) reduction of the blood pressure; (3) alteration of the pulse-respiration ratio; and (4) sudden cessation of the respiration. The danger with ether approaches from the pulmonary rather than from the cardiac side—so that, by establishing artificial respiration, we have a means of warding off death. Its advantages are, to a great extent obviated by the use of ethidene; whilst the dangers of chloroform are also reduced to a minimum.

X.—*The History of Selenium, and its Action in the Bell Photophone, with description of a recently designed Form.* By ANDREW JAMIESON, C.E., Principal of the Glasgow Mechanics' Institution.

[Read before the Society, January 19th, 1881.]

SELENIUM.

Symbol—Se. Atomic Weight, 79·0. Vapour Density, 79·0.
Specific Gravity, 4·5 (varies according to condition.)

Discovery.—The discovery of the non-metallic element, Selenium, is due to Berzelius, who observed it in the deposit of sulphuric acid chambers at Gripsholm, in Sweden, in the year 1817, when attempting to obtain a new source of supply of the rare metalloid Tellurium. The word Selenium is derived from Σελήνη, the "moon," on account of its analogy to the element Tellurium (from tellus the "earth"), which had been previously discovered, and so named by Klapworth in 1798.

Where found.—Selenium is widely distributed, but only obtainable in small quantities from iron and copper pyrites, the smoke from the furnaces of silver works, the deposit in leaden chambers at sulphuric acid works, and it has also been found in the metallic chambers of commerce.

Chemical Modifications of Selenium.—Selenium appears in two chemical allotropic modifications, the one soluble and the other insoluble in disulphide of carbon ($C\ S_2$). The soluble modification has been called "Red Selenium," "Amorphous Selenium," and "Glassy Selenium," and is a bad conductor of heat, and a *non-conductor* of electricity; the insoluble variety (which is the element of interest this evening) has been called "Black Selenium," "Granular Selenium," "Metallic Selenium," and "Crystalline Selenium," and, as we shall see, conducts not only heat, but is, under certain circumstances, a good conductor of electricity.

Discovery of Electrical Properties.—Mr. Willoughby Smith, Electrician-in-Chief to the Telegraph Construction and Maintenance Company, was the first to bring prominently before the scientific world the curious electrical properties of Selenium. He was the inaugurator of an important system of electrical testing and signalling, in connection with the laying of long telegraph cables, in which it was necessary to employ very high resistances of many megohms, and, as a single megohm coil of well-made platinum silver wire costs about £80, his attention was drawn to the high resistance offered by Selenium to the passage of electric currents; and he found by employing this material that he could produce equally satisfactory results with it at a cost of £1 10s. Selenium was thus first introduced as of practical use in the important process of the laying of the 1873-74 Atlantic cables (and not 1866, as reported in *Engineering*). It has been found so well adapted to the purposes required, that the Telegraph Construction and Maintenance Company never fit out an expedition of importance without including resistance-boxes of this curious, and, as we shall see, subtle material.

Mr. Willoughby Smith soon recognised (with the assistance of Mr. May) the peculiar effect which light had upon the electrical conductivity of Selenium, and he brought before the Society of Telegraph Engineers several important communications (February 4th, 1873; March 8th, 1876; Nov. 28th, 1877), wherein he described a number of experimental data relating to this matter.*

Dr. Werner Siemens of Berlin, Dr. C. W. Siemens of London, Professor W. G. Adams of London, Lieut. Sale, R.E., the Earl of Rosse, and other electricians, took up the matter at this point, and proved several curious facts, a few of the results of which the author hopes to show you this evening.

It remained, however, for Professor Graham Bell and Mr. Sumner Tainter to discover, last summer, the possibility of the transmission of musical notes and speech by means of an undulatory beam of light projected from a vibrating disc upon a sensitive Selenium cell, in circuit with an electric battery and telephone. Following up Professor Bell's discovery, the author has just found out that musical sounds and speech can be transmitted by a gas flame (governed by the voice) acting on Selenium.

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* It was at Aden in January, 1880, on completion of the laying of the Eastern and South African Cable, that the author first thought of a scheme for automatic translation on long submarine cables by using Selenium. He there saw Mr. Willoughby Smith's high resistances, read his and other communications to the Soc. Telegraph Engineers; and afterwards at Malta drew out several plans for carrying the idea into execution. He is now working at it, believing it to be practicable and worth accomplishing.

Previous to Professor Bell's experiments the following facts had been elicited regarding the action of light and heat upon granular Selenium, viz., that it exhibits three different electrical properties according to the temperature and mode of treatment by which it is prepared.

Electrical Modifications of Selenium. I.—If prepared at a temperature not above 100° C., it is a very bad conductor of electricity, and does not acquire conducting properties on exposure to light, or a short exposure to moderate heat-rays (not above 100° C.).

II.—If melted quickly, and raised to 210° C., and maintained at that temperature for a short time, but cooled suddenly, it conducts moderately well, is poorly sensitive to light, and its conductivity increases upon exposure to heat.

III.—If melted and pressed between the wires of a gridiron-form of cell, then cooled, and afterwards carefully annealed by being raised to various temperatures between 120° C. and 215° C., and kept at the latter temperature for some time, and then very gradually cooled, the glossy appearance of the Selenium becomes changed to a dull slate or lead colour; the conductivity is generally very good, say from 500 to 3000 ohms in the dark, and about half that on exposure to light. Selenium thus prepared is very sensitive to light, and fairly so to heat. Some experimenters affirm that the conductivity decreases with rising temperature (at least within certain limits), and, therefore, the Selenium acts like a metal, but the author has in every case found that even a slight increase of temperature was accompanied by an increase of conducting power, or that light and heat had a similar effect.

No. III. is the best plan for securing a "sensitive cell;" but, as Selenium varies so much in quality, no hard and fast rule can be laid down for manipulating it.

Effects of Light, Heat, and Time on a Selenium Cell.—The conducting power of a cell is affected by time on exposure to light. That is to say, a momentary exposure will reduce the resistance, and a continued exposure will still further do so; but it takes a much longer time to regain its normal resistance after being so exposed, on being confined to darkness. For example, if exposed for a couple of seconds to the light from an ordinary gas burner, at, say, two inches distance, it will take several minutes at least to completely regain its original resistance on return to darkness. Daylight, and direct sun rays, have a much greater effect in reducing the resistance than gas or lamp light. Earl

Rosse and Dr. Werner Siemens showed that the variation in resistance of Selenium is proportional to the square root of the intensity of illumination. The author has found that a Selenium cell increases in resistance with age (see Table II. of Tests, No. 3 Cell, author's form). This is contrary to some results of Professor W. G. Adams (see Report Soc. Tel. Eng. Journal, Vol. VI., p. 442). Granular or "insoluble Selenium" has no definite melting point, as it softens gradually, like sealing wax, upon the application of heat, whereas the red or amorphous form has a constant melting point at 217° C., and both forms pass off in a dark reddish brown vapour at somewhere below 700° C. This vapour can be condensed either in the form of scarlet flowers of Selenium, or dark shining drops. Care must, therefore, be taken in dealing with this expensive material not to heat it too highly (say above 300° C.) The author mentions this fact, because he unwittingly allowed a piece under treatment to disappear into vapour while attempting to melt and smooth it down upon a cell with a redhot iron. He found, as far as the requirements for melting Selenium in the making of a sensitive Selenium cell were concerned, that the temperature need never exceed 215° C., and that the change from the glassy metallic high resistance condition to that of the crystalline or low resistance state takes place either in the act of raising or lowering of the temperature somewhere between 100° and 200° C., varying with the quality.

He also found that it is unsafe to use the Selenium scrapings from a cell made up with brass, or copper gratings (or wires) for a fresh cell, for the Selenium forms with the brass or copper an intimate mixture or amalgam [not a selenite of copper (Cu. Se.)], which readily conducts electricity like a metal, and is very liable to short-circuit, and thus spoil the new cell.

Mr. Willoughby Smith, and others, infer from their experiments, that the effect of light upon Selenium is so far independent of its accompanying heat rays, while some affirm that the heat rays conveyed by the light are at the bottom of the whole matter. Upon this point there is considerable divergence of opinion, and the author, after describing his form of cell, showing the effects of both heat and light thereon, by means of Sir Wm. Thomson's reflecting galvanometer, joined up in Wheatstone Bridge, will leave you to judge of the cause and effect for yourselves.

But first of all he will describe how Professor Bell constructed his sensitive cells.

EXPLANATION OF PROFESSOR BELL'S FORM OF SENSITIVE SELENIUM CELL ADOPTED IN HIS PHOTOPHONE.

Fig. 1 is a sectional sketch of the cylindrical form of Selenium cell employed by Professor Bell, and to which the name *Photopile* might be given. The cylindrical surface is the portion which is sensitive to light, the rays of undulatory light being thrown upon its cylindrical face by a paraboloidal reflector, in whose focus it is placed. This beautiful little instrument consists of a number of circular discs of brass, about two inches in diameter, strung upon a rod passing through their common centre, and separated from one another by a similar series of discs of mica whose diameter is slightly smaller than that of the brass discs, so as to form with the latter (when the whole is built together as a cylinder) a number of grooves around its cylindrical surface. The discs are held firmly together by nuts and bolts passing through them, two of which—b_1 and b_2—are shown in the diagram, and which form the connecting screws for placing the instrument in circuit with a pair of telephones and a battery.

(A)

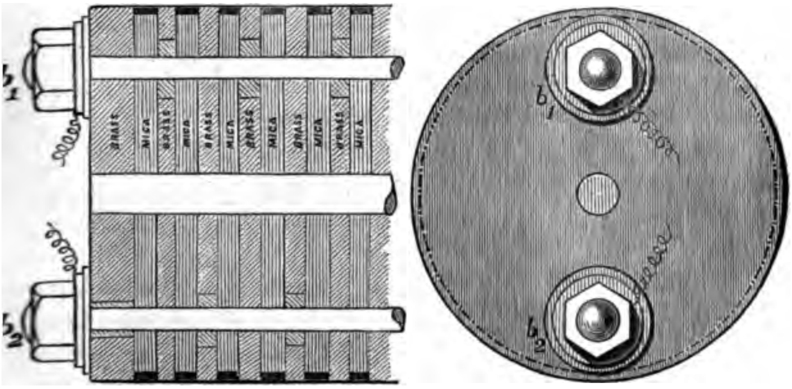


FIG. 1.—*Longitudinal Section.* *End View.*

Every *alternate* disc of brass is in metallic connexion with the the upper bolt (b_1), but is insulated from the lower bolt (b_2), and *vice versa*. The grooves formed around the cylindrical surface are filled in with Selenium by the following process: the cylinder is first heated to a temperature somewhat above that of the fusing point of Selenium (214° C.), and, while hot, a stick of Selenium is rubbed over its surface, filling up the grooves and covering the edges of the brass discs. The cylinder is then put in a lathe, and the Selenium is turned off until the edges of the brass discs are bared. Before being sensitive to light, however, the Selenium has to be annealed by first heating it until signs of fusion begin to show themselves; when the heat is removed, the fused portions re-crystallize, and the Selenium is thereby rendered both sensitive to light, heat, and a conductor of electricity.

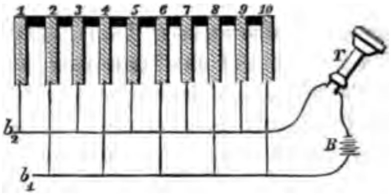


FIG. 2.

Fig. 2 is a diagram in which the connection of the brass discs with the external or telephonic current is more clearly shown. Here it will be seen that the discs numbered 1, 3, 5, 7, and so on, are connected to one terminal of the telephone T by the wire from b_2, while the even discs, 2, 4, 6, 8, &c., are in connection with the other terminal through the wire b_1 and battery B.

The Author's Form of Selenium Cell.—While trying to construct a cell according to the above directions laid down by Professor Bell, the author was struck with the mechanical difficulty, time, and expense, necessary to make a good one, and he was also unable to make Mr. Shadwell Bidwell's form, not having a screw-cutting lathe at hand; so, after trying several plans, he fell upon the following simple, and at the same time quick and inexpensive, method shown in Fig. (*a*), and on the black-board to audience, as well as showing model and how made :—

A Glass plate or tube, $\frac{1}{16}$-inch thick, $1\frac{1}{2}$ inches wide, and 4 inches long, upon which are tightly wound *two separate silk or cotton covered copper wires;* for about 3 inches along the middle of the plate or tube, leaving the ends of the wire free, but tucked in by a sailors' serving hitch, so as to keep them from slackening and unreeving. A red hot poker or iron is now applied to the darkened part marked (Selenium), so as to burn off the insulating covering (silk or cotton) from that part (1 inch by 2 inches) and thus leave a series of *bare* parallel copper wires, separated from each other by the double thickness of the silk or cotton covering, say ($\frac{1}{50}$-in.). These copper wires are now carefully cleaned and brightened by glass-paper, and the blank cell placed about 2 inches above a Bunsen burner, with a sheet of tin-plate and mica intervening, see Fig. (*b*), so as not to burn the under side of the insulating cotton or silk, or inserted in an air bath as in Fig. (*c*).

The temperature of the *blank* cell is now raised to 215° C or thereby, and a bar of Selenium carefully rubbed over the surface of the bared wires and parallel with them, not crosswise, for fear of short-circuiting them by contact. Very shortly a coating of melted glossy Selenium will cover the surface of the spaces between the bared wires. When such has taken place, allow the cell to cool, and gently scrape off any superfluous Selenium, until the wires almost appear, taking care not to use these scrapings for a fresh cell, for the author has already remarked he found to his cost and trouble that the Selenium seems to form an intimate mixture with the copper which readily conducts electricity, and upon using it for another cell, he short-circuited and spoiled it. The cell is now treated as explained for Plan III., being gently heated to about 210° C., kept for some time at that temperature, and very gradually cooled and annealed. The surface of the Selenium, under this operation, changes from a glossy to a dull slate colour, and the structure becomes crystalline. It is well to have the cell joined up during the whole operation with the Wheatstone Bridge and reflecting galvanometer, and to take frequent balances of the resistance, in order to ascertain how matters are progressing, and to note any sudden change or possible short-circuiting (as well as temperature, according to Fig. *d* and table next page). The gradual cooling is easily performed, by elevating the ring of the stand, and the temperature of the surface Selenium should be noted from time to time by thermometer. The author found that by keeping on a constant current from a battery of 6 Leclanché cells, the resistance fell more quickly, and lower, than without it, during annealing, but he could not observe that any beneficial effect was obtained by doing so, for after the battery was removed the resistance rose again. With a stronger battery, 24 Leclanchés, he observed some cells polarize slightly like a fault in a submarine cable, the resistance decreasing with current from the zinc pole, and increasing with that from the carbon. There is a turning point about 213° C. (see table) where the resistance again rises, and the author did not carry the temperature very high for fear of spoiling the cell.

TABLE I.

Table showing times, temperatures, and corresponding resistances, with remarks when annealing circular form of cell No. I. in hot-air bath, according to Figs. C. joined up in Wheatstone Bridge, without Telephone in circuit.

January 14th, 1881.

Time in Air Bath.			Temp. C.	Res. in ohms.	Remarks.
			100 rising.		6 Leclanché Cells used, cell put in cold at 10° C. after scraping off surplus Selenium.
12.45 p.m.	H.	M.			
	0	5	130°	4000	Res. falling with increasing temperature, cell in perfect darkness the whole time.
	0	10	140°	2300	
	0	35	160°	1700	
	0	45	185°	800	
	0	48	195°	650	Behaving like a dielectric.
	0	50	200°	440	
	0	55	210°	300	
	0	56	210°	290	At 213° C. the res. changed from decreasing, and rapidly rose with a few degrees of increasing temperature. Behaving like a metal.
			213°	Change.	
	0	58	215°	350	
1.45 p.m.	1	0	218°	600	
	1	35	140°	295	Lowered temp. and cell fell again in res. Left cell to cool very gradually, taking various readings.
	2	45	125°	350	Resistance rising again.
	2	55	110°	360	
	3	15	100°	360	
	3	18	90°	340?	Cell removed, and allowed to cool, afterwards tried with singing flame, and distinctly heard the note in Telephone.

TABLE II.

History of No. 3 Flat Cell, made up December 27th (3 p.m.), 1880, showing increasing Resistance with Age.

Date.	Temp. C.	Resistance in Ohms.		
		In Dark.	In Light, about 2 in. from Gas.	Difference in Ohms between Dark and Light.
1880—Dec. 27	About 100° C.	530	—	—
,, 28	—	2700	1690	1010
,, 29	About 15° C.	3180	1620	1560
,, ,,	After several exposures to light.	2250	1120	1130
—	—	—	—	—
1881—Jan. 10	—	3300	2350	950
,, 14	Nearly freezing.	6700	2900	3800
,, 15	About 5° C.	6900	3200	3700
,, 19	After handling and exposure.	6200	3900	2300
,, 19	At Lecture. — Warm room about 20° C.	5740	2340	3400
,, 22	After Lecture.—After long confinement to darkness, 10° C.	8500	3440	5060
,, 24	9° C.	z&c 8500	3040	5460
,, 25	9·5° C.	z&c 8500	3100	5400
,, 26	6° C.	z&c 9900	3940	5960

The following tests have been taken since (up to time of appearing in print) :—

Date.	Temp. C.	Resistance in Ohms.		
		In Dark.	In Light, about 2 in. from Gas.	Differennce in Ohms between Dark and Light.
1881—Jan. 28	9·3	8300 (very damp day)	4940	3360
,, 31	10°	9740	4270	5470
Feb. 3	12°	9540	3500 (near Gas)	6040
,, 16	11°	10,000	4700	5300
,, 17	11°	9730	4370	5360
,, 21	10°	11,100	5170	5930

The above cell answers admirably and truthfully; and the author cannot detect any diminution in its power of reproducing singing and speech, in fact, it seems to have greater resilience than when younger and of lower resistance. He is therefore led to believe that cells of very low resistance —say 300 ohms—are not so good as those of from 3,000 to 10,000 ohms.

N.B.—The author is carefully testing this cell daily, and hopes to get a co-efficient of resistance for temperature thereby.

Selenium Cell in circuit with Wheatstone Bridge and Te
Fig. d.—By joining up the Selenium in the above way (Fig.
the galvanometer and telephone, the alteration of resistanc
cell on exposure to light or heat rays, is very prettily shown
movements of the light "spot" of the galvanometer, and by
in the telephone, thus seeing and hearing simultaneously th
of rays of light or heat falling on the Selenium cell. Th
exhibited to the meeting, but the effect of light was much
than a corresponding temperature from a (dark) hot piece

Explanation of Fig. e.—The author then explained th
of an intermittent light, according to Professor Bell's pla
the Selenium cell, by apparatus kindly made for him by
G. Graham of the Glasgow Telephone Exchange, and a lim
from Mr. White the optician. The apparatus (Fig. *e*) con
a revolving disc (A) with *ten* equally pitched holes, one
diameter, moving at any desired speed parallel to a fixed pl
with a single hole, so that a beam of light projected from th
light upon this opening was free to pass and impinge up
sensitive cell (C) whenever any one of the holes in A was
to that in B.

The result of the above experiment is, that a note can b
in the telephone corresponding to the number of times per
that the light is free to pass through the opening in the pla
and reduce the resistance in the Selenium cell.

Explanation of Professor Bell's Photophone, Fig. 3.—W
come to Professor Bell's Photophone. In the large d
hung on the wall, of which Fig. 3 is a copy, you will
general arrangement shown in section, and here on the t
the apparatus in detail before you:—

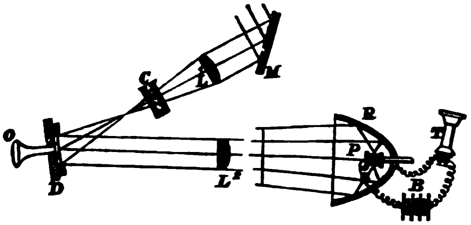
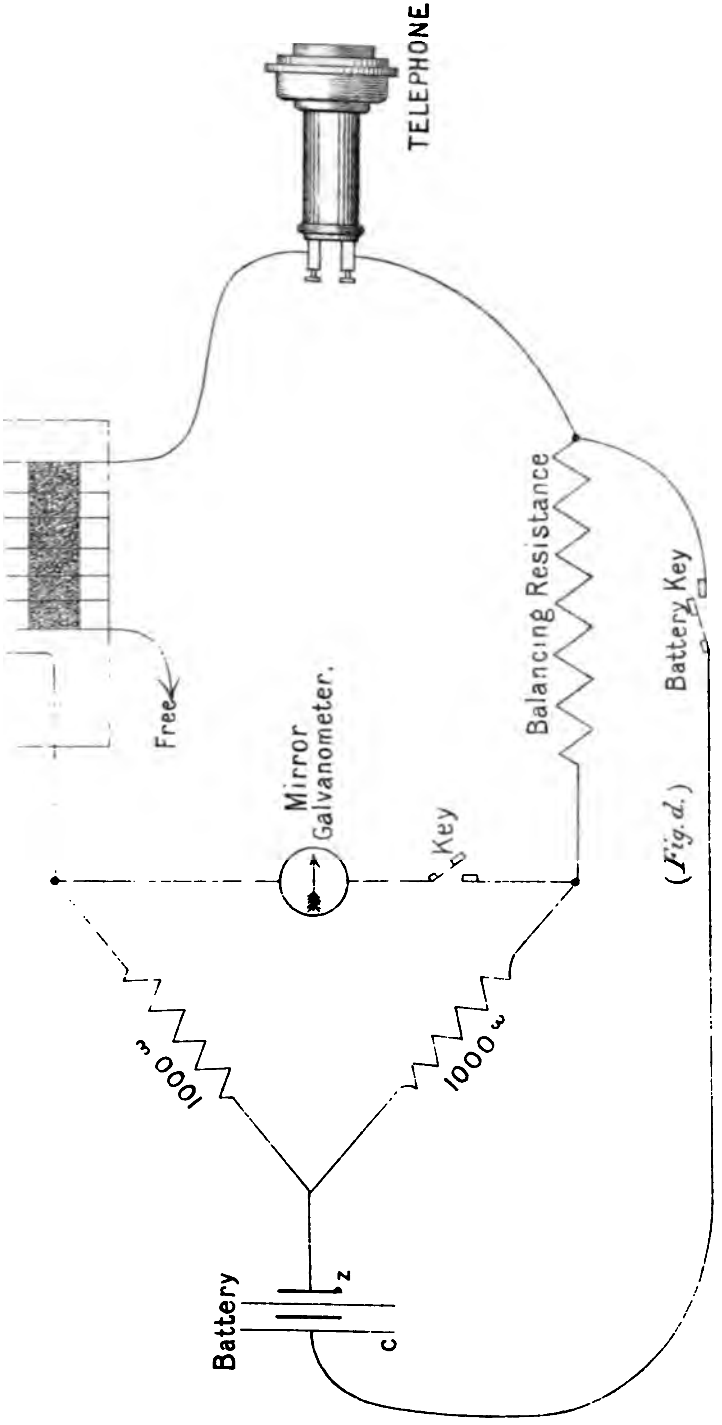


FIG. 3.

The portion to the left of the figure is the transmitting app
and that to the right the receiving instrument. The ray

PHONE


TELEPHONE
Free
Mirror Galvanometer.
Key
Balancing Resistance
Battery Key
1000 ω
1000 ω
Battery
z
c

(*Fig. d.*)

XII.—*The Wire Telephone.* By Professor JAMES BLYTH.

[Read before the Society, 16th February, 1881.]

IT is well known that the action of all telephones, worked by electricity, depends upon the variation of the current strength in the circuit produced by the source of sound; and, hence, all telephones may be divided into three great classes, depending upon the three distinct ways in which the current strength in any electrical circuit can be varied.

We know from Ohm's Law that the current strength in any circuit is expressed in terms of the proper units, by the quotient of the electro-motive force, which sends the current through the circuit, and the resistance which it encounters; or, in symbols, if E represent the electro-motive force, and R the resistance, and C the current strength, we have $C = \frac{E}{R}$.

Now the fraction $\frac{E}{R}$ can be varied in three distinct ways—*first*, by varying E and keeping R constant; *secondly*, by varying R and keeping E constant; and *thirdly*, by varying both E and R simultaneously, but in such a way that the ratio $\frac{E}{R}$ is altered.

These three ways of varying the current strength give rise to the three distinct forms of telephone.

The best example of the first class—that is, of those which are worked by varying the electro-motive force, and keeping the resistance constant—is the ordinary Bell telephone.

The second class—that is, those worked by varying the resistance and keeping the electro-motive force constant—includes the various forms of loose contact or microphone telephones, whether used as transmitters or receivers. This class also includes the wire telephone in one of its forms.

The examples of the third class are as yet comparatively few, and, although they possess great scientific interest, they cannot be said to have much practical importance. To this class belongs the wire telephone in one of its forms, and also the new red phosphorus telephone, of which I shall have to speak presently.

By a wire telephone is simply meant a wire more or less fine, inincluded in a circuit, which conveys a varied or interrupted current, and to which is attached some form of apparatus for intensifying the sounds produced by the variation of the current strength.

In what follows we shall suppose ourselves in possession of a wire circuit, including a battery, and we shall also suppose that there are two gaps in the circuit—A and B—distant from each other, and into which various forms of transmitter and receiver can be readily inserted. Throughout we shall denote the sending station by A and the receiving station by B.

The earliest and simplest form of wire telephone is that due to an observation first made by De la Rive. He found that, when an interrupted current passed through a circuit, sounds could be heard proceeding from the wire when it was placed close to the ear. This result can be very readily shown by the following method, due to Dr. Ferguson :—

Place any form of make-and-break at A, and insert a moderately-fine wire at B, to which is attached a string telephone. The sounds of the make-and-break at A will be distinctly heard proceeding from the string telephone when held close to the ear. It has been found that these sounds are loudest when an iron wire is inserted at B, and that they are varied when the iron wire is heated by a spirit lamp. It is clear from this that the magnetic susceptibility of the wire has something to do with the effect, as has been shown by Prof. Chrystal and Dr. Ferguson.

Let us next place a tuning fork interrupter at A and the electric sonometer at B.

This last consists of an ordinary monochord, with a wire stretched between the bridges, and through which the current is led. Astride this wire stands a strong electro-magnet, with pointed poles so placed that the points are close to the wire, but leaving it freedom to move up and down in a vertical plane between them. The electro-magnet is worked by a separate battery of 8 or 10 Grove's cells. When the magnet current is turned on, and the tuning fork set agoing, a loud sound is heard proceeding from the monochord wire, and this sound is greatly intensified when the distance between the bridges is so adjusted as to bring out the fundamental note or any of the harmonics of the tuning fork. The wire is also seen to vibrate rigidly up and down in the vertical plane, across the lines of force, due to the magnet. We have obviously here a timed motion, which accounts for the loudness of the sound, and by properly adjusting the tension of the wire it can be made to divide very beautifully into nodes and loops. The sound produced is very much the same with copper and steel wires, which shows that it is not confined to magnetic metals alone.

As a modification of the last experiment, let us place at A the violin-microphone, and at B a fine iron wire, to the middle point of which, and at right angles to it, is attached the thread of a large string telephone, made out of a toy drum.

A tune played at A is very distinctly reproduced at B, and it is rendered still louder by placing a magnet over the wire at B. When no magnet is present, the sound here is obviously caused by the heating and cooling of the fine iron wire by the passing of the current. Under this effect the wire will lengthen and shorten and so give a series of pulls to the parchment drumhead.

I have found that this form of receiver can also act as a transmitter to an ordinary Bell telephone employed as receiver. To show this, let the wire telephone be inserted at A and a Bell telephone at B, when it will be found that a song uttered into the drum will be reproduced in the telephone. This experiment succeeds best when a small string telephone with a mica disc is used. The sound is also greatly increased by placing a magnet across the fine iron wire. In this case we have both a variation of the electro-motive force and the resistance taking place. The electro-motive force is varied by the movement of the wire across the lines of force due to the magnet, and the resistance is varied by the heating and cooling of the wire.

It is obvious that in this experiment we could employ several wires at B, and get the heating effect produced in each of them. Suppose a series of such fine wires to be placed there, and then imagine their lengths gradually shortened, in order that the heat produced in each may be greater. If we continue shortening, we shall at last come to a set of wires infinitely short—that is, to a set of mere points in contact; and this reduces us at once to a multitude of loose contacts acting as a receiver. The experiment can be shown as follows:—Still using the violin-microphone, let us place at B a jelly-jar, filled with fragments of carbon or small screw nails, through which the current is led.

It will now be found that, with a moderately strong battery in the circuit, a tune played at A is reproduced at B out of the jelly-jar. It is somewhat difficult to see how the resistance at B, and the heating and cooling effect there, acting upon the surrounding air, is varied so sympathetically as to reproduce even musical sounds. I have also found that the violin-microphone at A can be replaced by a precisely similar jelly-jar as that used at B. When this is done songs, and even articulation, to a certain extent, uttered into the jelly-jar at A are reproduced at B.

While investigating the cause of this result, I was led to employ at B, instead of a multitude of loose contacts, a single loose contact, which could be perpetually renewed. This was managed by arranging the receiver in the form of what Professor Chrystal has called the grindstone telephone. It consists of a darning needle, with its point bent at a right angle, placed so that the point presses lightly on the circumference of a bismuth drum, which can be slowly turned by hand. The other end of the needle is attached to the centre of the mica disc of a phonograph mouthpiece. The current is led from the needle point to the bismuth cylinder, and the violin-microphone is used as transmitter.

When a tune is played at A it is faintly reproduced at B, even when the cylinder is still, but it is very remarkably intensified when the cylinder is slowly rotated. Here there must be a strong heat produced by the current as it passes from the needle point to the cylinder, and, as I imagine, an incipient fusion takes place there, which, in a manner, makes the metals stick together. This adhesion is broken by the rotation of the cylinder, and again takes place when a new point of contact is made. These stickings and lettings-go give a series of rhythmical jerks to the mica disc, which accounts, as I think, in great part at least, for the sounds produced. This explanation is also borne out by the fact that the experiment succeeds better with bismuth than with any other metal which I have tried. Now, in looking over the appropriate tables, I find that bismuth possesses both the lowest specific heat and also the lowest thermal conductivity of all metals. On both these accounts the heat produced at the needle point by the same current in the same time would be obviously greater for bismuth than any other metal. It is noticeable also that we have here in contact the strongest paramagnetic and the strongest diamagnetic metal—steel and bismuth respectively. Whether this may have anything to do with the effect, I am unable to say.

While experimenting recently with the photophone, I was led to try various substances as a substitute for selenium, and, amongst others, amorphous phosphorus. Although I found the red phosphorus insensitive to the action of light, I discovered, curiously enough, that it could be used in the double capacity of battery and loose contact as the transmitter in a telephone circuit. That it acts as a voltaic cell is shown by placing a thin layer of it between two parallel plates of iron or brass, and joining the plates to the terminals of a galvanometer, when a strong deflection of the spot of light is observed. By reversing the wires the direction of the deflection is reversed, although there is no very evident reason why an elementary substance between two similar metal plates should produce a current in the one direction more than the other. It depends, however, I believe, greatly upon the number of points of contact being greater on the one plate than on the other. I have observed also that the deflection varies when pressure is applied to the plates, and that in some cases the direction of the current changes by pressure.

I have constructed a telephone transmitter of the red phosphorus as follows:—A shallow wooden box is made, and a brass plate placed at the bottom of it, to which one electrode wire is attached. The red phosphorus is then put in, and a thin brass membrane placed on the top, to which the other electrode is attached. A mouthpiece is arranged, whereby the voice can be directed against the thin brass membrane. Where this is inserted at A and a Bell telephone at B, and without any battery in the circuit, sounds uttered into the transmitter at A are distinctly reproduced at B. When a moderately-strong battery is included in the circuit, the sounds come out with singular clearness and loudness.

This is an example of the third class of telephones.

When a current is passed for a few minutes through the phosphorous transmitter, and then turned off, a hissing sound is heard proceeding from the phosphorus for several minutes after the current ceases.

I have not yet had time fully to investigate this action of the red phosphorus, and, in consequence, am unable to say how long the action would last.

XIII.—*Visible Speech, and its Application to the Teaching of the Deaf.* By T. H. JONES, Principal of the Greenock Articulation School, lately from the School of Vocal Physiology, Boston University, U.S.A.

[Read before the Society, 2nd March, 1881.]

THE system of Visible Speech, as its name implies, is a method of making visible to the eye the action of the vocal organs in producing speech, and is of British origin, having been invented by Alexander Melville Bell, F.E.I.S., F.R.S.S.A., Professor in Edinburgh; but Professor Bell having removed to America, the method was first extensively applied to the teaching of the deaf in that country by his son, Alex. Graham Bell, well known as the inventor of the telephone, and later of the photophone.

The lecturer described Visible Speech as the result of Professor Bell's belief, after many years' study of phonetics, that a scientific alphabet might be made, based on the action of the vocal organs; and, after overcoming the many difficulties that presented themselves, in 1864 he completed a set of physiological symbols, in which the sounds of all languages may be written, and, as by this means the mechanism of speech is made visible to the eye, he called the system Visible Speech.

In the alphabet of Visible Speech each organ or part of organ used in articulation is distinguished by a simple symbol, pictorial of the part used; also, the relation of the parts to each other is pictured in a similar manner, so that each letter or symbol representing any sound shows at once what organs are used, and how they are placed in making that sound.

In the alphabet of Visible Speech every letter has a fixed phonetic value, which is the same in all languages, every sound has its own appropriate symbol, and each part of every letter a definite physiological meaning. The uses to which this system have been applied are many and various. Among those noticed were its application to the learning correct pronunciation of foreign languages, to remedying defects of speech in hearing persons, to the teaching of elocution; while its utility in the mission field was evidenced by its use in China by the Rev. Mr. Murray, missionary from Scotland, who used the system in translating large parts of the New Testament into the Chinese spoken language, for the use of the uneducated classes. The Chinese spoken language and the Chinese written language are two entirely distinct tongues. The Chinese spoken language had never been written or printed until Visible Speech was used for that purpose. Coming to the application of the system to the teaching of the deaf, the speaker described the trial of the system in the Boston School for Deaf Mutes, the results of which were so satisfactory that a Training College for Teachers was established. The system was gradually adopted by other schools, and within the last ten years over twenty public and private institutions in

America have introduced the system. The plan of work was then explained, the two great objects to be gained being—1st, To teach the pupil articulation, or how to express his or her own thoughts in spoken language; and, 2nd, to understand the speech of others, by watching the motions of their vocal organs; this is called lip-reading.

In the teaching of articulation the child is first introduced to a chart, on which is drawn the profile of the human face, showing the inside of the mouth and the vocal organs. Each of these organs, or part of organs, has a simple mark or symbol which distinguishes it, and the pupil learns to recognise these symbols at sight.

The next step is to combine the symbols to represent the various positions the organs assume in speech, and to require the pupil to place the organs in the position pictured by the symbol. Thus the pupil becomes able, at sight, to take any position required, and the teacher, knowing the positions necessary to produce any sound, has only to combine the symbols, and the pupil sees at once how he may produce the sound with the certainty of being correct, although he cannot hear it. Strange sounds, which nearly all deaf persons have, are utilised by leading from them to others, and then dropping the useless and disagreeable ones.

This was illustrated by writing upon the board, in the symbols, the inarticulate and uncouth sounds, which were the only ones the younger pupils could give when they first came under instruction, and, by eliminating some of the symbols and adding others, from these uncouth sounds English letters were obtained. From one of these, by striking out the symbol representing a trill of the lips, and adding the symbol for voice, the sound of "th" was obtained, as in "then," and from this one sound no less than twenty-six other English sounds may be obtained by the directive power of the symbols. Thus, one by one, the sounds of our language are obtained; these are combined into syllables and words, and these again into sentences. After the pupil acquires power to articulate, force, pitch, and inflection are taught, the voice becoming more and more soft and pleasant as the pupil advances.

Turning to the subject of lip-reading, some of the difficulties which the deaf meet with in learning to understand the speech of others from the motion of their vocal organs were noticed—one among them being the difficulty of distinguishing between homophonous sounds, which require the same position of the vocal organs, and differing only from each other by one requiring a puff of breath, another a pure tone, and another a nasal tone, &c.

These differences easily distinguish themselves to hearing ears, but the deaf fail to perceive them. They see but the one position for all three, and judge which sound is intended by the connection in which it (the sound) is used.

Here, however, Visible Speech again came to the pupil's aid. These homophonous sounds in our language are carefully classified and symbolised in Visible Speech, and their combination with other sounds in English words noted, and thus the pupil's difficulty in knowing what sound was really uttered is very much diminished.

The advantages of Visible Speech, as proved by experience, were thus summarised :—1st, The system is phonetic, each of its letters representing but one sound, and every sound having its own invariable letter. 2nd, It furnishes a means for picturing to the pupils just the position of the vocal organs necessary to produce any sound, and this, in the case of obscure sounds, is invaluable, 3rd, Faults of articulation can be clearly represented to the eye of the pupil, and by the symbols he can gauge the correctness of his speech, although he cannot hear it. 4th, Strange and uncouth sounds, which many deaf persons have, may, by the directive power of the symbols, be utilised to form proper sounds, and so, instead of a hindrance, may be made a positive help to speech. 5th, Homophonous sounds, or those requiring the same position while really differing from each other, may be so classified and symbolised that the difficulty of recognising them may be much lessened.

The practical results of the system of Visible Speech were here illustrated by various exercises with the pupils of the Greenock Articulation School, including purely oral exercises in arithmetic, grammar, geography, visible speech, English money, use of capital letters, and concluding with the recitation of the 23rd Psalm and Tennyson's poem, "Break! break! break!" by members of the school, the pupils of which were all totally deaf, their ages ranging from seven to eleven years.

XIV.—*Artificial Indigo.* By ARTHUR G. PERKIN.

[Read at Meeting of Chemical Section, March 7, 1881.]

INDIGO has been known for many centuries, both as a dyestuff and a drug—in fact, its use as such dates back to the remotest antiquity. It was known to many Eastern nations, and was at first supposed to have been originally imported from India; but it was subsequently found to have been in use by nations having no intercourse whatever with that country. Pliny, in his writings, acquaints us with the fact that it was known to the Greeks and Romans, and the mummy cloths are sufficient evidence of its use among the Egyptians. However, its great value as a dyestuff was not known till the end of the sixteenth century, when it was introduced from India into Europe by the Dutch. Its use then was strongly prohibited, both here and throughout Europe, due, doubtless, to the opposition of the growers of the woad plant *(Isatis tinctoria)*, which was then an important industry. Gradually, however, it superseded the woad, and early in the eighteenth century came into use in full force.

Indigo occurs in a genus of plants named *Indigofera*, which are found in India, Africa, America, &c. There are about sixty species of this plant, but those from which the colour is usually extracted are the *Indigofera Argentea, Anil, Disperma*, and *Tinctoria*. The colouring matter in these and the other *Indigoferae* is wholly in cellular tissue of the leaves, and that not in the blue state in which we usually see indigo, but as a white substance, which remains so as long as the leaf is unhurt.

Dr. Schunk has made some very interesting researches on the subject of this white body in the *Isatis tinctoria*, and finds that it consists of a peculiar glucoside, which he terms indican, and which easily splits up into indigotin and a sugar called indiglucin, as follows:—

$$\underset{\text{Indican.}}{C_{26}H_{31}NO_{17}} + 2\,H_2O = \underset{\text{Indigo.}}{C_8H_5NO} + \underset{\text{Indiglucin.}}{3C_6H_{10}O_6}$$

he Processes of extracting the colouring matter from the plant are essentially ones of fermentation, but it would be quite unnecessary for me to enter into the details of them. The finest commercial indigo is by no means pure, containing as a rule from twenty to thirty per cent. of foreign matter, consisting of such bodies as clay, iron, magnesia, &c. The percentage of indigo in samples in the market varies from about 12 to 75 per cent. To obtain the pure article from any of these, one of the best methods is to proceed as follows :—

Powder the crude indigo finely, and, after digesting it with dilute sulphuric acid, filter and wash. Next digest the residue with strong potash, filter, wash again, and finally boil the residue with strong alcohol. It is, perhaps, better after this to crystallise it from aniline, or sublime it, as there is not unfrequently a little silica present.

Pure indigo is of a deep bluish-violet colour. It is tasteless, inodorous, and perfectly neutral. Its best solvent is aniline, from which it is easily crystallisable. It is insoluble in ether, alcohol, alkalies, and dilute acids. Indigo volatilises at 290° C., a process which is always accompanied by partial decomposition, unless it be quite pure. If it be finely powdered, mixed with anhydrous acetic acid, and a single drop of strong sulphuric acid added, a deep blue liquid results, and if any woven tissue be dipped in this and immediately afterwards washed with water it will be found to be dyed blue. This process is the only manner known in which indigo, without reduction, can be applied in its primitive state. With sulphuric acid it yields sulphopurpuric acid, or sulphindigotic acid, according as the acid is fuming or the ordinary concentrated.

The first accurate analysis of indigo was performed by the late Mr. Walter Crum, a pupil of Dr. Ure, who found it to have the following composition :—

$$C_8H_5NO,$$

which formula has been doubted, for certain reasons. It is isomeric with cyanide of benzoyl—

$$C_7H_5OCN.$$

For years this body has been studied, and numerous and very interesting researches have been made upon it. I shall, however, as far as possible, keep to those bearing directly upon my subject.

As early as the year 1840 Fritzsche found that, when indigo was fused with caustic potash, ammonia and aniline were given off.

This reaction is of great historical interest, being the first by which aniline was ever prepared.

He also found that, when indigo was boiled with an aqueous solution of potash and peroxide of manganese, he obtained a body which he termed anthranilic acid, now known as orthoamidobenzoic acid, $C_6H_4 (NH_2) COHO$.

In the year 1841, Erdmann & Laurent, by the aid of oxidizing agents on indigo, obtained a body of the following composition, which they termed isatin:—

$$C_8H_5NO_2.$$

This body is the anhydride of isatic acid $C_8H_7NO_3$. The best oxidizing agent is either chromic or nitric acid, the yield with the latter being about 12 per cent. of indigo started with.

We now come to some of the many researches of Professor A. Baeyer, of Munich, which have at length led to the most probable production of "Artificial Indigo" on the large scale.

Fourteen years after the discovery of isatin, he, in conjunction with C. A. Knop (Jahrs. Ber., 1866, page 638), succeeded, by acting on that body with sodium amalgam and water, in obtaining a substance which they found to have the following formula:—

$$C_8H_7NO_2.$$

This body, which was termed dioxindol, can also be obtained when an aqueous solution of isatin is boiled with zinc dust and hydrochloric acid.

Dioxindol is converted, by reduction in an acid solution, to oxindol, C_8H_7NO, and, when this is passed over heated zinc dust, it is further reduced to indol C_8H_7N.

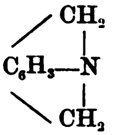
Indol occurs naturally as a normal constituent of the urine, and has been proved to be formed during the decomposition of albuminoids in the organism.

By administering indol to animals, and examining their urine some little time after such administration, indigo will be found to present.

Nencki was also able to produce indigo from indol by the action ozonised air. This appears to have been the first way by which indigo was prepared synthetically.

Baeyer's efforts were now directed in trying to obtain an easier method for the production of indol, which at that time was regarded by him as the mother substance of the indigo group. I will quote his own words on the subject:—

He says—"If indol is to be prepared synthetically, there must be introduced into the benzol a two-limbed carbon chain and an atom of nitrogen, and the two must be united with each other." —(Ber. Tan. 10, page 2255.)



He succeeded in 1868, together with Emmerling, in obtaining it from nitrocinnamic acid, which contains all that is requisite for the formation of indol. It will be noticed, on an observation of the formula of this body, that it differs only from indol by carbonic anhydride and two atoms of oxygen—

$$\left\{\begin{array}{l} C_8H_6NO_2 \\ CO\,HO \end{array}\right. -CO_2 - O_2 = C_8H_7N$$

and, by fusing it with caustic potash and iron filings, the removal of these is accomplished. Shortly after this, Kékule made some experiments on nitrophenylacetic acid, with a view to obtain isatin from it, in which he was unsuccessful. Nevertheless, about this time he predicted a formula for indigo, which is, in all probability, the right one, and is now universally held.

A very neat synthesis of isatin was effected by Claisen and Shadwell, two pupils of Kékule, in 1879, which is accomplished as follows :—

Orthonitrobenzoic acid is treated with phosphorus pentachloride to obtain the corresponding chloride.

$$C_6H_5\,(NO_2)\,CO\,HO \qquad C_6H_5\,(NO_2)\,CO\,Cl$$

This is converted into the nitrile by means of argentic cyanide, which, by treatment with fuming hydrochloric acid, passes into the amide—

$$C_6H_4\,(NO_2)\,CO\,CN \qquad C_6H_4\,(NO_2)\,CO\,CO\,NH_2$$

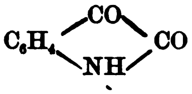
By acting on this with caustic potash orthonitrophenylglyoxalic acid is formed—

$$C_6H_4\,(NO_2)\,CO\,COHO,$$

which, by reduction with sodium amalgam or ferrous sulphate, goes into isatic acid—

$$C_6H_4\ (NH_2)\ CO\ COHO.$$

Finally, on treatment with hydrochloric acid, this is converted into isatin—



Baeyer and Emmerling in 1870 discovered a process by which isatin could be reduced back to indigo. This they accomplished by heating it in a heated tube to 75 or 80 Cent., with a mixture of equal parts of phosphorus trichloride and acetylchloride, together with a little free phosphorus. This method is not satisfactory, however, for there is produced in large quantity at the same time as indigo another colouring matter called indigopurpurin. This body is isomeric with indigo.

Seven years after this a very simple and elegant method for preparing indol was contrived by Baeyer and Caro—viz., by passing the vapour of ethylaniline through a red-hot tube.

$$\underset{\text{Ethylaniline.}}{C_8H_{11}N} = \underset{\text{Indol.}}{C_8H_7N} + 2H_2$$

It has been found that other similar derivations of aniline, under like conditions, yield indol, and that diethylorthotoluidine gives the best results.

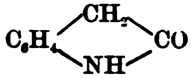
In 1878 Baeyer succeeded in obtaining indigo from phenylacetic acid, a body easily obtainable from toluene. Now, this acid is converted, by means of nitric acid, into an "ortho" and also a "para" nitro compound. The former, when treated with a reducing agent, yields an amido acid. This gives off water with great facility, yielding oxindol.

The reactions may be represented thus :—

$$\underset{\text{Orthonitrophenylacetic acid.}}{\left\{\begin{matrix} C_7H_6NO_2 \\ CO\ HO \end{matrix}\right.} + H_6 = \underset{\text{Orthoamidophenylacetic acid.}}{\left\{\begin{matrix} C_7H_6NH_2 \\ CO\ HO \end{matrix}\right.} + 2OH_2$$

$$\left\{\begin{matrix} C_7H_6NH_2 \\ CO\ HO \end{matrix}\right. = OH_2 + \underset{\text{Oxindol.}}{C_8H_7NO}$$

The formula of oxindol may be written thus :—



$$C_6H_4\left\langle\begin{matrix}CH_2\\NH\end{matrix}\right\rangle CO$$

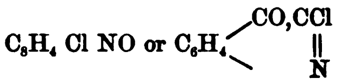
An observation of this formula shows us that if the CH_2 can be replaced by CO, isatin will result. This was done indirectly (Baeyer and Knop) by passing nitrous acid into an aqueous solution of oxindol, which caused the formation of nitrosoxindol, a body easily transformed by nascent hydrogen into the corresponding amido compound.

$$C_8H_6\,(NO)\,NO \qquad C_8H_6\,(NH)\,NO$$

This body, by oxidation, is transformed into isatin.

$$C_8H_5NO_2$$

The method before mentioned of converting isatin into indigo not giving good results, Baeyer made experiments with a view to obtain a better, in which he was successful. He found that when isatin was treated with phosphorus pentachloride, hydrochloric acid gas was evolved, and a body formed which had the following composition :—



$$C_8H_4\,Cl\,NO \text{ or } C_6H_4\left\langle\begin{matrix}CO,CCl\\ \quad\| \\ \quad N\end{matrix}\right.$$

By reducing this body (which is isatin chloride) with zinc dust and hydrochloric acid, he obtained indigo.

$$2\,C_8H_4\,ClNO \;+\; 2\,H_2 \;=\; C_{16}H_{10}N_2O_2 \;+\; 2\,HCl$$

The reducing agent giving the best results appears to be sulphide of ammonium, but all give, mixed with the indigo, more or less indigopurpurin.

I now come to two most important methods for the formation of indigo blue, discovered by Prof. A. Baeyer, one of which will most probably be the basis of its manufacture on the large scale. The starting point of both these processes is cinnamic acid.

$$\left.\begin{matrix}C_8H_7\\CO\,HO\end{matrix}\right\}=C_9H_8O_2$$

This acid was at first obtained by the oxidation of oil of cinnamene. It is also found in liquid storax, &c.

There are, however, two or three methods for the preparation of this body artificially. The best of these was devised by my father, Mr. W. H. Perkin, in 1877. It consists in boiling benzoic aldehyde with acetic anhydride and sodic acetate for about a day.

The first part of the reaction consists in the formation of the diacetate.

$$C_6H_5\ CH \left\{ \begin{matrix} C_2H_3O_2 \\ C_2H_3O_2 \end{matrix} \right\} = C_{11}H_{12}O_4$$

This is decomposed by the sodic acetate* as quickly as it is formed, yielding acetic and cinnamic acids, thus :—

$$C_{11}H_{12}O_4 = \underset{\text{Acetic acid.}}{C_2H_4O_2} + \underset{\text{Cinnamic acid.}}{C_9H_8O_2}$$

This is practically the process which it is proposed to use for the manufacture of cinnamic acid on the large scale, and it is found that, by substituting the benzoic aldehyde, which is now made from toluene, by an allied and cheaper derivative of that hydrocarbon, that cinnamic acid can be made at a less price than that of anthracene.

By treating cinnamic acid with nitric acid two isomeric nitroderivatives are produced—viz., the ortho and the para. These are separated, the former only being useful. The yield of the ortho, with proper precaution, is said to be much larger than that of the para (60 p.c.). By passing chlorine into a solution of this orthonitrocinnamic acid in soda, orthonitrophenylchlorlactic acid is formed.

$$C_9H_8ClNO_5$$

This body, by treatment with alcoholic potash, is transformed into orthonitrophenylacrylic acid—

$$C_9H_7NO_5$$

If this be carefully heated to 110 Cent. carbonic anhydride oxygen and water are given off, and indigo formed.

The second process is accomplished as follows :—Orthonitrocinnamic acid, when treated with bromine, takes up with great facility two atoms even in the cold, forming orthonitrodibromohydrocinnamic acid.

$$C_6H_4\ (NO_2)\ C_2H_2Br_2\ CO\ HO$$

---

* The part played by the sodic acetate is not clearly understood.

This, by the action of alkali (caustic soda), is converted into orthonitrophenylpropiolic acid, as follows :—

$$C_6H_4\ (NO_2)\ C_2H_2Br_2\ CO\ HO + 2\ Na\ HO = C_6H_4\ (NO_2)\ C_2\ CO\ HO + 2\ NaBr + 2\ OH_2$$

When an alkaline solution of this body is heated with a reducing agent, such as grape sugar, indigo is produced.

$$2C_9H_5\ (NO_2)\ O_2 \quad + \quad 2H_2 = C_{16}H_{10}N_2O_2 + 2CO_2 + 2H_2O$$

Orthonitrophenylpropiolic acid. Indigo.

This latter process gives the best results, and is much easier to conduct than the former.

I will now give you a few details with regard to the manufacture of indigo on the large scale by this process, as described in Professor Baeyer's patents :—

"One part by weight of finely-powdered orthonitrocinnamic acid is spread out in thin layers in a closed chamber. Near the roof of the chamber is a suitable vessel, containing excess of bromine (from $\frac{9}{10}$ths to 1 part by weight), which is left to volatilize at the ordinary temperature, daylight being excluded. The time required for the absorption of the bromine is, as a rule, from twelve to twenty hours, after which time the excess of bromine in the chamber is expelled by means of a current of air.

"The orthonitrodibromhydrocinnamic acid thus produced may be at once applied to the subsequent operations.

"Ten pounds or thereabouts of this acid are mixed with about a gallon of an aqueous solution of caustic soda, sp. gr. 1.4, and care taken not to allow the temperature to rise above 25° C.

"The whole is allowed to stand for two or three hours, or until a sample, after dissolving in water, precipitating with dilute sulphuric acid, filtering and washing, is found to be free from bromine. The result of the operation is then mixed with from three to five gallons of water, and the mixture treated with dilute sulphuric acid, which precipitates the orthonitrophenylpropiolic acid. After filtration the acid is washed with cold water, and dried at a gentle heat. Ten pounds of orthonitrophenylpropiolic acid are now mixed with 100 gallons of water, and a solution of five pounds of glucose in five of water is added. The whole is then gradually heated to 85° C., when 35 gallons of a saturated solution of caustic baryta are added, a little at a time. The mixture soon acquires a blue colouration, and indigo is precipitated in the crystalline state."

A portion of the mixture is filtered from time to time, and the filtrate tested for indigo, and when a sample no longer gives any large quantity of indigo blue the operation is considered terminated.

The mixture is then filtered, and the residue, after digestion with hydrochloric acid to remove alkali, is filtered, washed, and dried. The result is indigo in a pretty pure state. The great advantage of this process is that you are able to produce indigo on textures.

I have some cloth printed with a mixture of potash, orthonitrophenylpropiolic acid, and grape sugar, which I will expose to the action of steam. To show you how very little of this acid goes a long way, I might tell you that the mixture printed on this cloth contains only five per cent. of orthonitrophenylpropiolic acid.

For some time at least, I believe, it is intended to send orthonitrophenylpropiolic acid into the market for printing purposes instead of indigo.

The following directions for producing indigo in the fibre, by the decomposition of orthonitrophenylpropiolic acid, are given from Professor Baeyer's patent:—

Mix about one part by weight of orthonitrophenylpropiolic acid with one part by weight of cold water, then add gradually as much f a 30 p.c. solution of potassic hydrate as will be necessary to issolve and neutralise the acid. Mix this solution with about ten arts by weight of starch paste, and afterwards dissolve in the olour thus prepared about three parts by weight of carbonate of otash and about one-half part by weight of glucose. The colour s developed by from two to five minutes' exposure in an atmoshere of steam, and the operation of steaming is discontinued s soon as the reduction of the indigo thus formed begins to et in. The printed materials are aged and washed in the usual anner, and passed through a boiling soap bath to improve the olour.

If indigo can be produced artificially on the large scale it will be a matter of great importance, and, although it is improbable that the market value of the natural article will be affected to the same extent as madder has been since the discovery of artificial alizarin, there will be very possibly some reduction.

In 1878 the imports of natural indigo into the United Kingdom were valued at about £1,583,207, and in 1879 at £1,900,983.

Now cinnamic acid can be produced at such a cheap cost, there is every reason to believe that the manufacture of artificial indigo will become a commercial success, and then indigo will head the list of the many famous coal-tar colours.

XV.—*Analysis of Soaps.* By Cornelius Hope.

[Read at Meeting of Chemical Section, 4th April, 1881.]

In this paper to the Section I intend giving a method for the full Analysis of Soda Soaps, which I have used for some considerable time, and which I find to be useful in giving information as to how the soap has been made, and also as giving an exact analysis of it, which is much desired by some consumers, and not usually done by analysts. In some cases a much shorter analysis will suffice, but in a soapworks laboratory the full one will be very often wanted.

Before weighing off portions of the soap, I think it is absolutely necessary to cut off the outer skin, and take the inside, otherwise discrepancies will result, not otherwise to be accounted for. The skin is a very small portion usually of the bar or cake, and it would be a difficult operation to get the proper amount of skin on the different portions weighed.

Water.—The first thing to be done is to cut some thin shavings off the sample, weighing about 5 grammes, and place them in a small, tared, flat porcelain basin, and the exact weight noted. It is then put in the water bath, and heated until it ceases to lose weight. A night generally suffices for this purpose. When that is done, it is weighed in the morning, and a number of small holes made with a pin in the dried slices, and put in the bath again for a few hours, and re-weighed. If there is no further loss, as is generally the case, it is certain the soap is thoroughly dry.

Some chemists have condemned this method of estimating the water, because, they say, it fails to give off the last one or two per cent.; but I find that such is not the case, because, when a soap is dried as I have described, it will give no further loss, even if heated to its decomposing point.

Fatty Acids.—A portion of the soap, weighing about 5 grammes, in the form of miniature bars, is introduced into a separating funnel of about 120 c.c. capacity, and about 50 c.c. of water, at, say 100° F., poured in, then enough acetic acid to decompose the soap and leave a small excess, and, finally, about 50 c.c. of ordinary ether. The stopper is then put in the funnel, and the whole shaken until the soap is all dissolved. It is then allowed to settle for a few minutes, when the fatty acids will be found to have dissolved in the ether, and floating on the watery solution, which contains the soda, salts, &c. The bottom stopper is then opened slightly, and the watery solution of the salts allowed to *drop* slowly out, until it stops; then the top stopper is taken out, and the remainder of the water allowed to drop slowly out, until only a few drops remain, at which time the stopper is shut. The funnel is then filled up with water about 90° or 100° F., the stopper replaced and shaken for a minute or so, allowed to settle, and the same operation as before repeated. The washing is continued until the washings are neutral, at which point the last few drops are allowed to go out, taking care not to allow any of the ethereal solution to follow it. It is always necessary to open the bottom stopper first, as there is enough ether vapour in the funnel to cause an outward pressure, which, on opening the top stopper first, causes a few small drops of the ether solution to splutter out—a proceeding not to be desired, and which is effectually prevented by operating as described.

The *dropping* of the washings is to be carefully done, otherwise the washings will be found to have a skin of fatty acids floating on the surface, which, of course, would cause a low result, and therefore must be carefully guarded against.

The ethereal solution of the fatty acids is then poured out by the top of funnel into a previously tared beaker of about 150 c.c. capacity, and the funnel rinsed out with fresh ether. The beaker is then covered with filter paper, and placed on the top of the water bath until the ether is evaporated. If the odour still remains in the beaker, a few minutes inside the bath will remove it completely. If the water has not been completely removed from the funnel, a few small drops of water will be seen in the fatty acids, and may be removed by the addition of a few drops of absolute alcohol, and then heated inside the water bath until its odour is gone. The beaker is now cooled and weighed, and, when the tare is deducted, gives the weight of fatty acids in the quantity of soap taken.

Total Alkali.—For this determination I take 31 grammes of the soap and put it into a 500 c.c. flask, and dissolve, with the aid of heat, in hot water. 50 c.c. of standard sulphuric acid are then added, and the flask filled up to the mark. 100 c.c. are filtered off, put into a beaker, and titrated with standard pure caustic soda, using litmus as an indicator. The acid used is a normal one—1 c.c. = ·062 gramme Na_2O; and the soda is $\frac{1}{10}$th of that strength—1 c.c. = ·0062 gramme Na_2O.

Sodic Chloride.—To the above neutralised solution some solution of yellow chromate of potash is added, and then titrated with a decinormal solution of silver—1 c.c. = ·00585 gramme NaCl.

Free Alkali.—3·1 grammes of the sample, in thin shavings, are weighed off and dissolved in rectified alcohol, then filtered as rapidly as possible, and the insoluble matter washed with boiling alcohol. A few drops of alcoholic solution of phenol thalein are added to the filtrate, and then titrated with the decinormal acid. This gives the free alkali existing as hydrate, usually only a trace, or none.

Soda existing as Silicate and Carbonate.—The insoluble in alcohol is dissolved on the filter with hot water, carbonic acid passed into the filtrate to precipitate a trace of lime usually in it, then thoroughly well boiled and filtered. The filtrate is then titrated with the decinormal acid, using litmus as indicator.

Soda existing as Carbonate.—5 grammes of the soap are dissolved in rectified alcohol, washed as before, and the insoluble dissolved in water. The solution containing the carbonate and silicate is put into a flask fitted with a set of two "U" tubes, containing solution of baric hydrate, and decomposed with dilute acid, and the CO_2 boiled out into the "U" tubes. The baric carbonate is filtered off as quickly as possible, the excess of hydrate washed from it, and the precipitate titrated with standard decinormal acid.

Sulphate of Soda.—10 grammes of the soap are dissolved in water, decomposed with HCl, and the fatty acids filtered off. The filtrate is precipitated with $BaCl_2$, and finished in the usual manner.

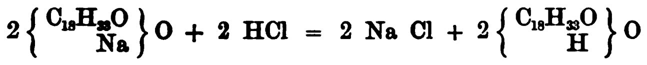
Silica.—25 or 50 grammes are ignited in a platinum basin, and the residue treated with HCl, evaporated to dryness, re-treated with HCl, and the insoluble silica filtered off, ignited, and weighed.

Lime, Iron, &c.—The filtrate from the silica is made alkaline with ammonia, some oxalate of ammonia added, the ppt. collected, ignited, and weighed.

CALCULATION AND STATEMENT OF RESULTS.

The water, silica, lime, &c., and sodic chloride, are simply calculated to per cent. The barium sulphate is calculated to per cent. of sodic sulphate. The alkali soluble in alcohol is calculated to Na HO, and the acid used for titrating the baric carbonate to sodic carbonate. The "soda existing as carbonate" is deducted from the "soda existing as silicate and carbonate," and the difference stated as "soda existing as silicate." The silica cannot be stated as silicate of soda, because the "silicate," as used, and as it exists in the soap, is not a normal one. It has an approximate composition of $Na_2O\ 2\ SiO_2$, but it is evidently not a definite compound, so that under those circumstances it is necessary to state the silica as such, and give the soda existing with it.

It was pointed out by a writer in the *Chemical News* some years ago, and seems to be still ignored, that, although in the process of analysis the fat is separated and weighed as fatty acid, it exists in the soap as fatty anhydride, as the following reaction, representing the decomposition of sodic oleate by an acid, shows:—



$$2\left\{\begin{matrix} C_{18}H_{33}O \\ Na \end{matrix}\right\}O + 2\ HCl = 2\ Na\ Cl + 2\left\{\begin{matrix} C_{18}H_{33}O \\ H \end{matrix}\right\}O$$

and that by multiplying the fatty acids by the factor ·97 the true weight of fatty matter existing in the soap was found.

If the "fatty acids" are stated in the analysis, it will be found that the analysis will total to nearly 102; therefore, because the per cent. of fatty acids is usually wanted, I generally repo analysis in the following manner :—

Per C

+ Fatty Anhydrides, ...
Soda existing as Soap, ...
Water, ...
Sodic Carbonate, ...
Do. Hydrate, ...
Do. Chloride, ...
Do. Sulphate, ...
Silica, ...
Soda existing as Silicate, ...
Lime, &c., ...

+ = °/ₒ Fatty Acids, ...
°/ₒ Total Soda, ...

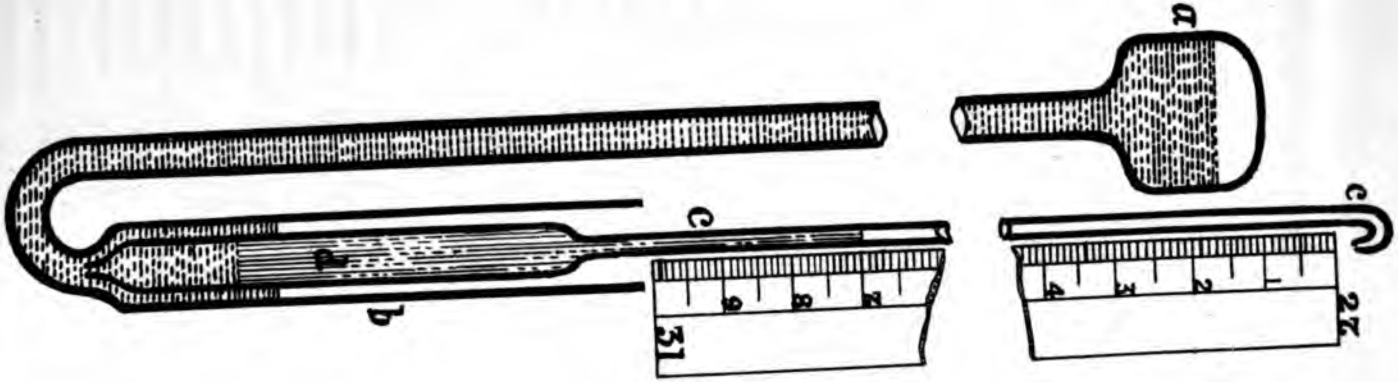
There are two other important points in connection with analysis—viz., the determination of the rosin and the melting of the fatty acids—that I intended to speak of in this paper, have not been able to get the experiments finished, so that I leave them for a future communication to the Section.

A method for the accurate determination of rosin in whether easy of execution or otherwise, is a thing still wante have been working lately at a method which, although not a one, promised well for accuracy, and which I now find t results short of the truth, because of the different rosinic in rosin having different solubilities in certain reagents.

XVI.—*On a Large-index Barometer.* By Mr. ALEXANDER

[Read to the Society, 30th March, 1881.]

THE design of instrument exhibited, and which has been in two years, is only intended to give the same indications



LARGE-INDEX BAROMETER. By Mr Alexander Scott.

ordinary mercurial barometer, but to give them in a magnified and more striking way. The movements of the mercury in an ordinary instrument being comparatively minute, require to be closely examined to be appreciated; but in the arrangement shown the variations of the index column can be made ten times as great if desired. [See Plate.]

The construction is very simple, and includes only two tubes. The first is equivalent to an ordinary mercurial barometer tube, and filled in the same way, but has a wide expansion (*a*) at the top, so that the greater part of the rise and fall of the mercury may be, not there (as usual), but in the lower limb (*b*). The second tube has a small orifice at both ends, and consists of a long small shank (*cc*) for the index column, with an expansion (*d*) at the lower end, partly immersed in the mercury in (*b*). In making the instrument, a small portion of a light fluid (such as spirits of wine, properly coloured) being filled into the wide part (*d*) by dipping, the orifice at the top is closed with the finger, and the tube, with the fluid, is inserted in the position shown. On removing the finger the mercury rises in (*d*), and forces the light fluid up into the narrow or index part (*cc*), until the difference in level between the mercury outside and inside (*d*) is balanced by the superincumbent column of light fluid, which then continues to give a correspondingly magnified indication of the mercurial variations from time to time.

Using spirits of wine, and making the internal diameters of (*a*), (*b*), (*c*), and (*d*), say in the proportions 12, 6, 1, and 4 respectively, the rise and fall of the index column is equal to about seven times that of the mercury in an ordinary barometer. Contracting the diameter of the expansion (*d*), or widening that of the shank (*c*), of course, diminishes the magnifying power, and *vice versa*.

Once the actual proportion is observed by comparison with a standard barometer, an index scale can be attached (the figures increasing downwards instead of upwards).

If great accuracy is desired, the effect of any slight taper in the glass tubes used must be allowed for by gradation in the index scale. Errors from variation of temperature can be almost wholly eliminated by merely restricting the capacity of the part (*d*) and regulating the quantity of light fluid used. As an increase of temperature, by diminishing the specific gravity of the mercury, requires a higher "head," which can only result from a rise in (*a*) and a (much greater) fall in (*b*) and (*d*)—the fall being little modified by increase in bulk of the mercury—it is only necessary to use, in all, no more of the light fluid than will, with the same increase of heat, give an expansion of volume just sufficient to fill the space left by the withdrawal of the mercury from (*d*), so that while the base of the column is depressed the summit is unaltered. The remaining errors are very minute.

XVII.—*Some Observations on our present Methods of Disposal of Human Excreta, and their Relation to the Spread of Epidemic Disease.* By Eben. Duncan, M.D., F.F.P.S.G.

[Read to the Society, 30th March, 1881.]

If the recommendations of the last deputation of the Glasgow Corporation, which reported upon the question of sewage disposal, are carried out, the excreta of the vast population of this city will continue to be disposed of as at present—about one-half by the dry method and one-half by water carriage. Looking at the matter purely from the point of view of a sanitarian, the modifications of existing methods, which they recommend, only affect to a very limited degree the sanitary problems which we have been discussing for so many years.

It is now well known that the most dangerous constituents of our organic refuse matter are human excreta.

Most of the common forms of epidemic disease—such as measles, scarlet fever, typhus fever, and small-pox—are known to be spread through the atmosphere. Although it may be true that, by dust collected in the houses of such patients, by water in which their persons are washed, or by the rags of clothing which they have worn, the germs of these diseases may gain access to the ashpit, manure heap, or sewer, yet up to the present time very little evidence has been adduced which connects outbreaks of these diseases with any of our ordinary methods of sewage disposal. Of all the epidemic diseases with which we are familiar, the one which has been most conclusively traced to air or water tainted with human excrement is typhoid fever. It is now proven most conclusively that the fever is propagated by the alvine discharges of those who suffer from it. Their poisonous effects are as clearly established as the poisonous properties of arsenic or strychnine. Wherever the drinking water of a community becomes tainted with these discharges, the fever appears. The investigations of the last ten years have all tended to prove that an outbreak of typhoid fever cannot arise in the absence of specific germs. Whether these germs are living or dead does not matter: they are derived from some pre-existing case. The old notion was that all forms of fever might arise *de novo* from the noxious vapours of decomposing organic matter. At the present time, noxious vapours of this description are only credited with the origination of typhoid fever and diphtheria. When the water-closet system was introduced into this country, going upon the old notion of bad smells breeding fever, every outbreak which happened in a water-closet town, the cause of which could not be easily ascertained, was attributed to bad smells from our sewers. And so arose the sewer-gas theory of the propagation of epidemic diseases. To this sewer-gas theory, which is a very popular one in the city of Glasgow, I wish first to direct your attention in the observations which follow.

It is very important that we should have all the light which careful observation can throw upon the possibilities of disease propagation by sewer gases, because, while the deputation already referred to recommend various measures for the precipitation of the sewage, and for the inspection of the drains and soil-pipes of houses to be built in the future, the water-closets and drains of existing Glasgow and its suburbs are left unchanged, and the masses of the people will be still as much exposed to the inhalation of sewer gases when these recommendations are carried out as they now are.

The late Dr. Murchison, of London, may be held to be the author of the modern view as to the propagation of typhoid fever by sewer gases. He published an essay in 1858, in which he endeavoured to prove that typhoid is the only fever which arises from sewer emanations. It is a well-known fact that the mere smell arising from the recent liquid discharges of the fever patient does not communicate the disease; and it is also a well-known fact that there are many trades in which numbers of men work daily with decomposing organic matter, and are subjected to the most noxious smells, without contracting fever of any kind In order to account for these difficulties, he asserted that the poison of typhoid fever was only generated during the decomposition of fæcal matter in a confined space, such as a drain or sewer in a state of stagnation. In the absence of any better explanation of the outbreaks of typhoid which occur in cities, the water supply of which is derived from pure sources, these views, first promulgated by Dr. Murchison, have been generally adopted. I shall quote a few extracts from various publications to show how strongly they are expressed at the present time. In a report to the Privy Council, Mr. J. M. Radcliffe states, "That the condition chiefly productive of diarrhœa and typhoid fever exists in its most dangerous form in improperly constructed and arranged and imperfectly acting or stagnant sewers containing excrement." At the conference on the Health and Sewage of Towns, held in 1878, Dr. Elliot, the Medical Officer of Health for Carlisle, concludes a paper on the dangers arising from defective soil-pipes and water-closets thus:—"The mention of a great and realised fact I may emphatically conclude with. It is this. That typhoid fever prevails pre-eminently more amongst the wealthier classes who have water-closets within their houses, than amongst the humbler classes who have outside closets." At the same conference, Mr. C. N. Cresswell expresses the popular view of the matter in the following still more emphatic but very erroneous statement:—"The system of sewage disposal by water carriage has produced a fresh type of zymotic disease, traceable to sewage sources, but especially to the vicious construction of houses, whereby typhoid fever is laid on with the same precision as hydro-carbon gas for the purposes of illumination. Dr. Murchison has distinguished this new revelation from its prototype typhus, and Dr. Fergus has proved abundantly that in Glasgow, where it has raged at intervals from the year 1836, it arose from a badly constructed system of flushing by water."

Of all those who have laboured to point out and remedy the defec of our water-closet system certainly our esteemed ex-Presiden Dr. Fergus, occupies the foremost place. By his discovery of t frequent perforations in our leaden soil-pipes, and by his numero publications on the multifarious defects of our house drains an sewers, he has certainly done a great service to the cause Sanitary Science. But what we are concerned with in this inquir is his reasons for connecting the prevalence of typhoid fever i Glasgow with these defects of sewerage. In a paper on the Sewag Question, published in 1872, having shown that all moder investigations agree in tracing outbreaks of typhoid fever to excremental pollution, he says—"In most of these cases the water was befouled, but, as this is a well-known cause of disease, and has been so amply proved, I shall not dwell upon it, but rather enter upon another source of typhoid and other zymotic diseases which is not so well known . . . perforated soil-pipes . . . ." After describing these and their causes, he goes on to say, "for some years back I have insisted on a careful examination of the soil-pipes wherever I have had cases of typhoid fever or diphtheria, and in every case where I could get this carefully carried out I have detected these perforated soil-pipes. What first led me to connect this state of the soil-pipes with disease was the fact that, as regards water supply, Glasgow should not be exposed to diseases resulting from excremental pollution; and if we have these diseases, we must attribute them to some other source." At that time Dr. Fergus adhered to Dr. Murchison's theory, stated above, and concluded that these cases were caused by gases generated from decomposing fæcal matter in the sewer gaining access to the houses through these perforated pipes. The same opinion, modified by the germ theory of disease, was expressed by Sir Thomas Watson in a recent number of the *Nineteenth Century.* He writes thus:—"During the prevalence of enteric fever in a large town a vast quantity of the dejections peculiar to that disease must be daily and hourly poured into and through the drains and sewers, impregnating the sewer gases with the specific poison. In our present faulty arrangements these gases, so infected, enter many a house, the inmates of which are unsuspicious of such a source of fearful peril. Mr. Rawlinson, the well-known engineer, has stated in print that in the year 1859 disinfectants were freely used in some of the main sewers of London, and 'the smell of the disinfectants was found to pervade all the houses in the district connected by drains with these sewers, showing to demonstration that such houses must, at all other times, be pervaded with diluted sewer gases.' Wherever (writes Dr. Budd) the alvine discharges from enteric fever patients travel—wherever exhalations from them concentrate—there the most specific of all the exuviæ of the sick body are in operation. *The sewer, which is their common receptacle, is the direct continuation of the diseased intestine.*" Looking to these statements, my first observation is, that if, with gases from sewers containing typhoid excreta, swarms of disease particles were really pouring into our houses at every crack or perforation in our soil-pipes, the result would have been disastrously different from what it has been in water-closet towns, as compared with country districts, which have no water-closets. Dr. Russell informs us that in Glasgow the greatest amount of typhoid fever, in proportion to the population, is found in small houses with no sewer connections whatever, and that, both in respect of typhoid fever and diphtheria, we compare very favourably with the rural districts of Scotland. Another theoretical objection to the above views has arisen in the minds of those who now hold the germ doctrine. The poison of this, as of other zymotic diseases, is now held to be a particle, and most advanced sanitarians believe it to be a living germ analogous to the organisms found in vaccine lymph, small-pox matter, or, perhaps, analogous to the infective germs of splenic fever.

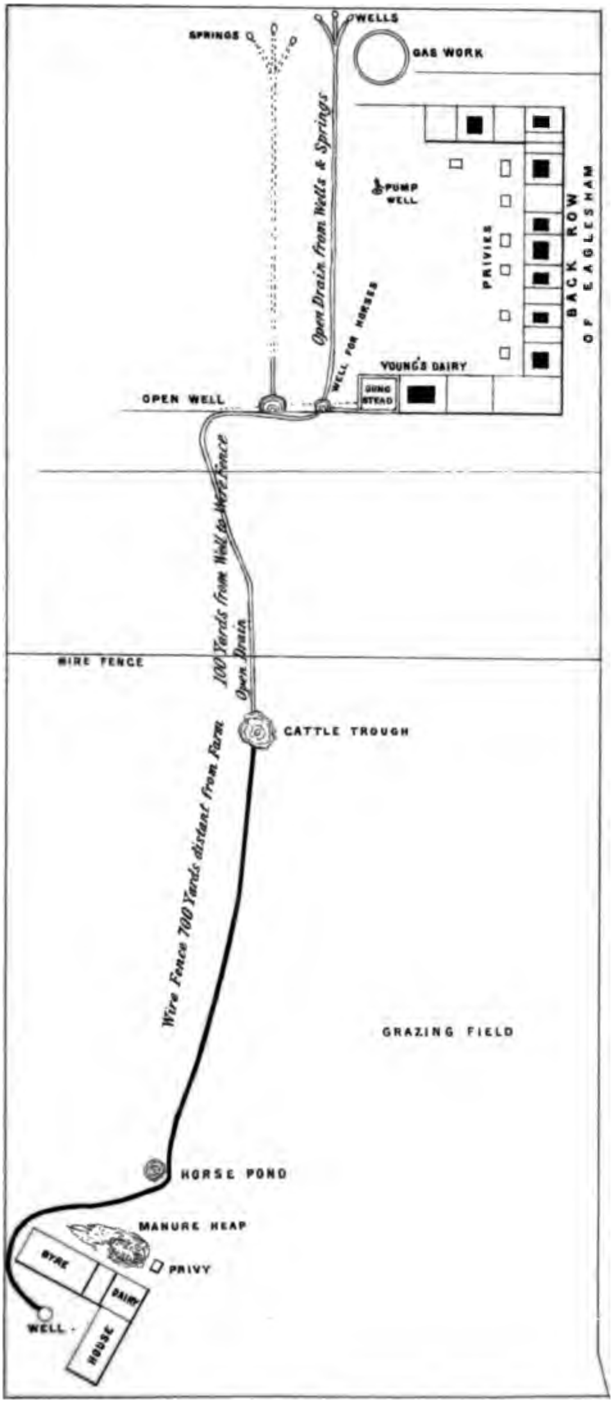
A few years ago it was commonly believed by scientific men that in the process of evaporation, and in the evolution of gases from decomposing organic fluids, the resulting vapours and gases carried into the atmosphere quantities of the minute particles which are known to abound in such fluids—viz., the germs of bacteria, and, by analogy, the germs of such diseases as are supposed to resemble these. But recent experiments have shown that this opinion has no solid foundation. In a paper read before this Society last session, Dr. Carmichael established, by the most complete experimental evidence, that, although small and unimportant amounts of sewer gases did pass through water traps, the germs of bacteria could not be got to do so. Mr. Mactear, in some experiments, read before this Society in 1874, had previously recorded the same fact. His experiments are all the more interesting because they were made with the special object of trying to get these germs to pass through the water of the trap. But Dr. Carmichael establishes a more important fact. He proves that neither in evaporation nor in gaseous emanation from decomposing organic fluids do the vapours carry with them the germs of bacteria, however numerous these may be in the fluid. I was very much interested in this discovery, because I had stated six years ago as an opinion, based upon my own personal observation of disease, that sewer gases did not propagate typhoid fever to any serious extent even when quantities of the specific discharges of typhoid patients were flowing and exhaling vapours in our sewers. In the numerous milk epidemics which have occurred in Glasgow and its neighbourhood since that time, we have now a means of testing the truth of that assertion, and of making further observations on the behaviour of sewer gases impregnated with the vapours arising from typhoid excreta. Before entering upon this inquiry, I wish to point out that the kind of evidence on which the propagation of typhoid fever by contaminated water or milk is founded is essentially different from the kind of evidence on which its propagation by sewer gases is based. In the first case we can generally prove that at a particular time the poisonous discharges of a typhoid fever patient or patients got access to the water, or the milk; and we can further prove that, within a certain definite period of time from this occurrence, the disease broke out among the people who drank of it. We can generally compare these people with a larger mass of the population in the same vicinity who were supplied with pure water, and pure milk, and who remained unaffected by the disease.

In the other case the supposed cause is in constant operation, and the whole community is exposed to its influence. Until lately we could not explain why, in a city like Glasgow, where sporadic cases of the fever are constantly present with us for months, the masses of the people should be exposed with impunity to an atmosphere tainted with these sewer gases, and then by some mysterious influence in a circumscribed locality a large number of people should be simultaneously struck down as if by poison.

My attention was first directed to this subject in the spring of 1875, when I was engaged in investigating the causes of a severe epidemic of typhoid fever in Crosshill. Having a large share in the treatment of the affected families, I began, from the first appearance of the disease, to take notes of every circumstance connected with my patients and their surroundings which seemed to me to have any bearing on its causation. As the sewer gas theory was at that time universally held by sanitarians, I was inclined at first to blame the drainage, and endeavoured to find faults in all the houses in which the fever occurred. Although in some houses I did discover glaring instances of defect, which gave a colour to that theory, I failed in most instances to find anything wrong with the plumber work or house drains. What puzzled me most was that the fever broke out simultaneously in various localities which had entirely different systems of drainage, and in one house which had neither drain nor sewer. Having read accounts of two epidemics of typhoid fever—one in London and one in Glasgow—in which the disease was supposed to be conveyed through milk contaminated by the fæcal discharges of typhoid fever patients, I turned my attention to the milk supply. I need not trouble you with the difficulties I encountered in this inquiry. They were detailed in a pamphlet which I published at that time. Of 68 cases of fever treated by me in Crosshill and its neighbourhood from 18th of January, when the epidemic began, till the end of March, when it suddenly terminated, 67 got their milk either wholly or partially from four dairies which were supplied by an Eaglesham milk agent. I therefore directed my inquiries to Eaglesham, and I shall give you a brief account of what I learned there.

About the end of November, 1874, a boy, aged 7 years, sickened of typhoid fever in the house of his grandfather, a dairyman and carter, who lived in house marked No. 1 on the map. At the same time his sister, who lived with her parents in house marked No. 2, sickened with the same disease. These children were in the habit of playing with rag-bags which their grandfather carted to a mill in the neighbourhood, and which were often thrown down at his door. It was supposed that these bags had contained pieces of cloth contaminated with typhoid discharges, and that the children had inhaled the poisonous dust from these rags.

During the course of his illness, which lasted for several weeks, the poisonous discharges of this dairyman's grandson were thrown into the dungstead figured upon the map. The drainage from this dungstead actually ran into an open well which was used for washing and watering the carter's horses, and for washing clothes. The overflow from this horse well ran into the gutter, and was conducted past the mouth of another open well, which supplied the inhabitants of the back row with drinking water. After every shower of rain the contents of this gutter overflowed into well No. 2. In this way a communication was established between the typhoid discharges in the dungstead and the drinking water of the inhabitants. Following upon this, during the ensuing month of December, 20 cases of typhoid fever occurred in the back row. There was no fever in any other part of Eaglesham. While these 20 cases were running their course a severe frost prevailed, during which the poisonous discharges of these 20 patients were thrown into the privies and dungsteads behind their houses, and there frozen up. Then followed rains, by which this five weeks' accumulation of filth and typhoid virus was washed down over and through a bed of gravel, into the water-course indicated upon


WELLS
SPRINGS
GAS WORK
PUMP WELL
PRIVIES
BACK ROW OF EAGLESHAM
Open Drain from Wells & Springs
WELL FOR HORSES
YOUNG'S DAIRY
DUNG STEAD
OPEN WELL
100 Yards from Well to Wire Fence
Open Drain
WIRE FENCE
CATTLE TROUGH
Wire Fence 700 Yards distant from Farm
GRAZING FIELD
HORSE POND
MANURE HEAP
PRIVY
BYRE
DAIRY
WELL
HOUSE

he map. This water, after joining the drainage from the dairy-nan's dungstead, formed an occasional source of water supply o one of the farmers whose milk was sold in the Eaglesham dairies n Crosshill. This farmer had a well beside his dungstead, which vas fed by a spring, but the water so supplied to it was sometimes nsufficient for the wants of his dairy. He found it necessary to ill up his well occasionally with water conducted by a pipe from he horse well in Eaglesham, above mentioned. When his well vas full he diverted this Eaglesham water into a horse-pond, the verflow of which watered a neighbouring meadow. When the rost broke up in the end of the first week of January, having run hort of water, he turned on this poisoned water supply, and eplenished his well. In due time, allowing for the known period f incubation, two of his children took typhoid fever. They ickened in the end of January, and for the three or four weeks luring which the fever ran its course their poisonous discharges vere thrown into the dungstead, and, as shown in the plan, had very opportunity of draining into his well. This water, so oisoned, was used for washing the milk dishes, and we may uppose that at every rinsing of the milk cans a quantity sufficient o poison the milk was left in every can or pail. We need not ccuse the farmer of any intentional dishonesty in such circumstances. The result of the importation of this milk to the four Eaglesham dairies in Crosshill is seen in this table of cases of typhoid which I personally attended. I have noted here the day on which the first symptoms of the illness showed themselves. It will be observed that the cases are grouped so as to indicate apparently two epidemics:—

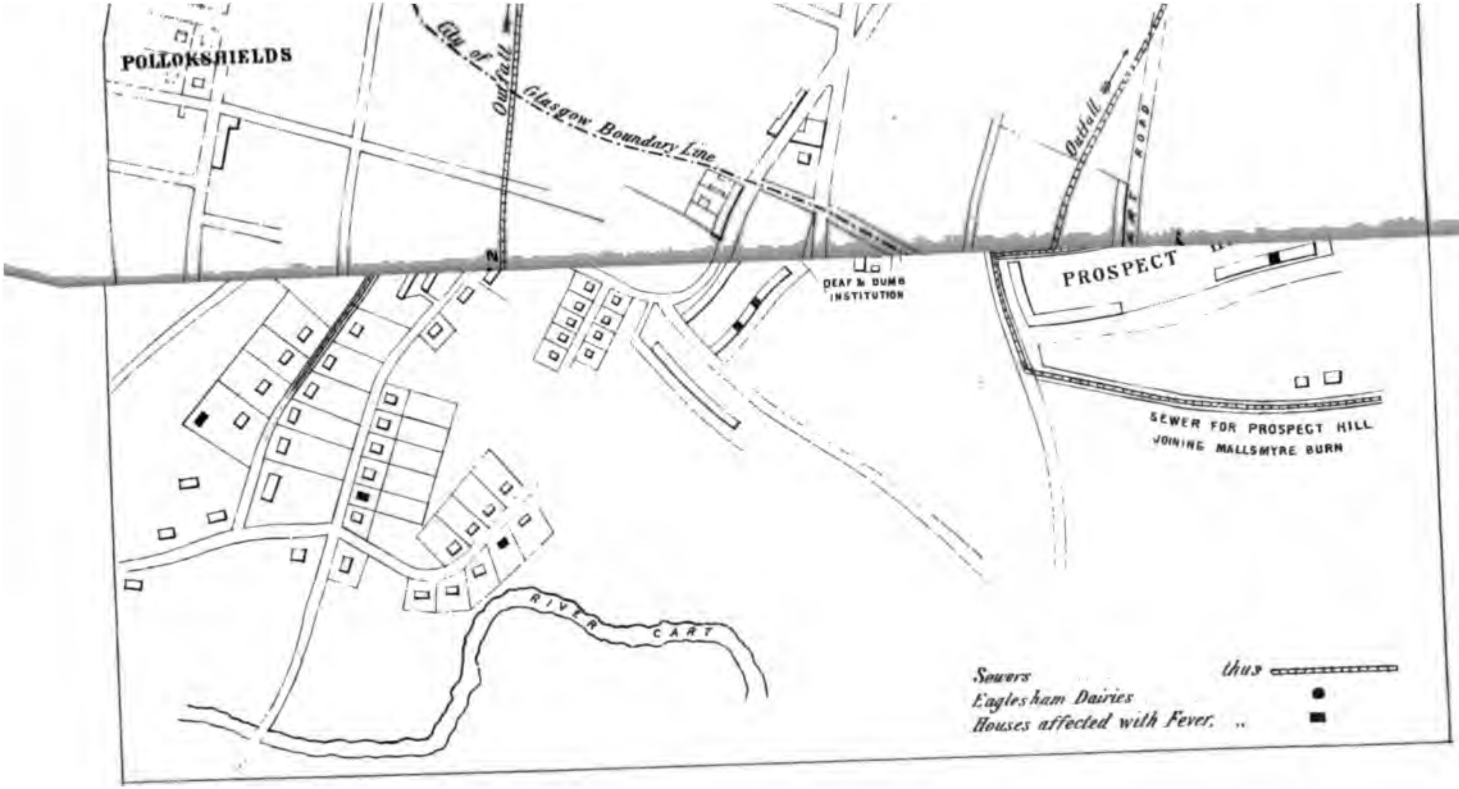
FIRST EPIDEMIC.

January 18th till January 24th inclusive,	6 cases
" 25th " 31st "	3 cases
February 1st till February 5th, "	2 cases
No cases from February 5th till February 15th.	

SECOND EPIDEMIC.

February 15th till February 21st inclusive,	13 cases
" 22nd " 28th "	16 cases
March 1st till March 7th inclusive,	18 cases
" 8th " 14th "	2 cases
" 15th " 21st "	4 cases
" 22nd " 28th "	4 cases
	68 cases

There is a period of incubation in this disease, varying from a few days to four weeks, during which there is no symptom of the poison germinating in the patient's body. It is therefore evident that when the farmer filled his well, in the second week of January, with the poisoned water from Eaglesham, he not only poisoned his own children, but he poisoned also, through his milk tainted by this water, the people of Crosshill. In this way we account for the first epidemic. My explanation of the interval which apparently elapsed between the first and second epidemic periods is this: The disease in the back row of Eaglesham came to an end—burned itself out, so to speak—in the beginning of January, and by the end of that month the accumulation of virus in that locality had been washed away by the rains. Had the farmer's children not been poisoned we would have had no more of it. But when their discharges began to soak into the farmer's well the disease broke out afresh in Crosshill. The typhoid discharges being in this case close at hand, the well became more poisonous than before, and so what I have called the second epidemic was worse than the first. I communicated the result of my inquiries to the Burgh Authorities, and on the 26th of February the dairy proprietors of Crosshill were interdicted from selling any Eaglesham milk. The epidemic came to an end within the period of incubation from that date. I do not think it possible that we can ever have more conclusive proof of a milk epidemic than we have here. Wherever that milk was carried, there the disease broke out in tenements and houses draining into sewers running north, south, east, and west, and having no connection with each other. I need not occupy your time further with proof of the milk origin of this epidemic. For further details I refer you to my pamphlet, of which two copies may be found in the library of this Society. Assuming that this Eaglesham milk was a sufficient cause for the fever in the case of those who could be proven to have partaken of it, the question I have now to consider is—Was the disease propagated to any extent by emanations from the sewers which received the poisonous discharges of these patients? In the pamphlet above referred to I stated a number of facts which led me to believe that, under ordinary conditions, sewer gas would not propagate typhoid fever, even when typhoid excreta were present in the sewers. Since I published that statement I have, as opportunity offered, made further inquiry into the circumstances of the affected families whom I did not personally


POLLOKSHIELDS
City of Glasgow Boundary Line
Outfall
Outfall
ROAD
2
DEAF & DUMB INSTITUTION
PROSPECT
SEWER FOR PROSPECT HILL JOINING MALLSMYRE BURN
RIVER CART
Sewers thus
Eaglesham Dairies ●
Houses affected with Fever. .. ■

attend, and also into the condition of the house drainage of the tenements most severely affected by the fever at that time. I shall now give you in detail the results of a few such inquiries, which have an important bearing on the question at issue. I have here a plan of the sewerage of the affected district. Into sewer No. 1 I ascertained that the discharges of 220 fever patients were thrown during the continuance of the epidemic. Every affected house had a water-closet draining into this sewer.

After receiving the sewage of Crosshill, this sewer runs to the north-east through a district which has since been formed into a burgh and named Govanhill. At the time of the epidemic it was divided into "No Man's Land"—in which one of the Eaglesham dairies was situated, and which was therefore, to the extent to which it was supplied by this milk, a fever-stricken district—and the Cathcart Road district, in which the milk supply was entirely derived from other sources. Through these two districts a mass of typhoid poison was draining daily and hourly for three months, exhaling the gases which are supposed to be such deadly factors in the spread of the disease. Every house in these districts had a water-closet draining into this sewer, with all the usual defects which water-closets possess in houses built by speculative builders.

Bordering on the fever-stricken district there were 8 tenements of houses, inhabited by 59 families; these 59 families were eriously annoyed by smells from their water-closets, and by great eficiency and irregularity of their water-supply. They shared in e popular belief that bad smells cause fever, so that, when the ver broke out in their immediate vicinity, they became terrified, d appealed to the sanitary authorities of the district to have ir houses inspected and the defects remedied.

The report of the inspector was published in the *Glasgow rald* of 20th February, and showed that if sewer gases could y typhoid germs, they had ample cause for fear. The report was as follows:—

A. The houses in this tenement are supplied from a cistern in garret, which is fed by a ½-inch supply pipe, having ¾-inch ice pipes from cistern to water-closets and jawboxes in houses. e cistern, which is 3 ft. 10 in. long, 2 ft. 9 in. wide, and 2 ft. p, was empty at the time of my visit, and there was no water ning into it, therefore the whole tenement was without water. he *overflow pipe of cistern is untrapped, and a strong current of* *sewage gas blows up through the pipe, which I think must,* n *less, contaminate the water."* . . . . "The water-closet stair in close was very dirty; the basin, which is cast-iron, ta from seat to floor, has no proper flushing apparatus, having pipe bent over the side; the inside of the basin is conseque a very filthy state. The floor has a step down of 8½ in., a floor was covered with filth.

"B. This tenement I found to be in all respects the same but the water-closet in close, the door of which was nail being opened, I found the soil-pipe chocked, and the excret flowing the seat, and the floor covered with it. It appe have been in this state for a long time, as the filth was c with white mould. The smell was most offensive, and alm bearable." The reports for tenements marked C, D, E, and similar; no traps in overflow pipes of cisterns; sewage gas admitted; on the ground flats filthy water-closets; only these six tenements had water in the cistern at the time inspector's visit.

G and H had kitchen jawboxes supplied from the main complaint of want of water, except in top flats. Two uprig pipes in each tenement, only one of which was ventilated.

On the 22nd of April, when the epidemic was at an visited these tenements and found that the conditions descri the above report remained unchanged. The owner of the pr refused to remedy the defects, and the sanitary authority— at that time no burghal powers—could not compel him to There is nothing said in this report about the trapping house drains, but as a strong current of gas was found to b ing back from the drain, through the overflow pipe of the we may assume that if there were traps of any description house drains they did not act. Quite recently the house d one of these tenements was uncovered, on account of an in of rats, and as two disconnecting traps were found in the drain of that tenement, we may assume that the others, whic erected by the same builder, were in a similar condition. 59 families were, therefore, living in direct communication sewer which contained a large amount of the fæcal discha typhoid fever patients. This sewer was, according to ou medical authority Dr. Budd, corroborated by the opinion Thomas Watson, "the direct continuation of the diseased inte of fever patients, and exhaled, what he terms, "the most

ERRATUM.

Page 166, line 33 from the top, for "*two* disconnecting traps," *read* "*no* connecting traps."

all the exuviæ of the sick body." What was the result? On e 22nd of April, when the epidemic was at an end, I visited ery one of these 59 families, and inquired into the state of the mily health, and as to the milk supply. Only 8 of these families d been supplied either wholly or partially with the poisoned ilk, and 4 of these families had contracted the fever, and there d not been previously, nor was there at the time of my visit, a ngle case of fever in the remaining 51 families who were inhaling e gases of this poison-ladened sewer.

When we trace this sewer a little further, we come to a popula- on of 3,500 in the Cathcart Road district, whose milk supply was ite different from that of Crosshill. Every house had a water- oset draining into this sewer. I made careful inquiries after the rosshill epidemic came to an end, and could only hear of two ses of typhoid fever as having occurred in this population during e course of the fever in Crosshill. One of these cases was known have been imported from Glasgow. How the other case origi- ted I did not make out. The houses of these people were of a ry poor description, and the drainage was known to be very perfect. Seven tenements of houses in this district, which were habited at the time I speak of, have since been discovered to ve no traps of any description on their house drains. In four these seven tenements the water-closets were situated in the ntre of the houses, and entirely unventilated. Other twelve nements, which were also inhabited at this time, although their use drains were supposed to be trapped, were built on the same an—an unventilated water-closet being in the centre of each parate house. In nine tenements the house drains were so badly id that they have since been found to be completely choked up. ne tenement was supplied with an ingenious arrangement for sting the typhoid-generating powers of fæcal matter. A large uare box, meant to form a V trap, had been placed under the gstone of the common entry, and the house drain was laid with fall in the direction of the houses. For two years the excreta d been stagnating under the basement of this tenement, yet no phoid was known to have occurred in any of these houses during is time. Finally, in four of the tenements occupied at the time the epidemic, the common soil-pipe was found to ventilate into attic, which contained the common cistern for the water supply. r all these facts I am indebted to Mr. Steel, the late chairman the Sanitary Committee of Govanhill, who has taken a great interest in sanitary matters, and visited these tenements personally to ascertain the facts.

Let us now consider the case of sewer No. 2, which was built by the city authorities to drain the Queen's Park and the houses fronting the Park. Eight villas and a terrace of six tenements of houses, called Royal Crescent, drained into the sewer. Thirty cases of typhoid fever occurred among the people inhabiting these houses. As I then resided—and still reside—in Royal Crescent, I had special opportunities of knowing all the facts with regard to the drainage arrangements, and the other circumstances of the affected families. I shall state in some detail the case of Royal Crescent, in which 25 cases of fever occurred. Here is a description of the state of the drainage of these houses, written by Dr. Fergus, our late president, who made a careful examination of the house drains. I quote from an article on the sewage question, published by him in the *Sanitary Journal* for December, 1878:—

"Two years ago I was requested to inspect a range of good, recently-erected, houses where typhoid had prevailed. We found the drains and rain water-pipes from the houses passing into a large cesspool at a higher level than the exit pipe into the drain, the outlet being several inches under water.

"The surface of the water in the cesspool was covered with floating fæces in a state of active decomposition. On this being stirred, sewer gas was given off freely. I desired that all the baths, sinks, and fixed basins in the houses should be fully turned on; but not one particle of fæces escaped, the whole mass only kept swirling round and round, the water escaping from below. In order to convince some parties who were sceptical, the process of flushing was repeated day after day, and the result was always the same. Let us inquire what became of the gas so generated. The cesspool was covered with an impervious stone lid, hermetically closed, so that none could escape into the open air, and it could not pass into the sewer on account of the large body of water which interposed. It must of necessity have been driven back, either into the houses or up the rain-water pipe. Typhoid had been introduced by milk; but I think it was clearly proved that it had spread by the decomposition of typhoid stools in this laboratory for the manufacture of sewer gas."

I was present at the inspection which Dr. Fergus made, and can testify to the accuracy of his description. The statement as to cases of fever having been propagated by the gases arising from these cesspools further inquiry has rendered exceedingly doubtful. Since that time I have carefully inquired into the circumstances of every family in the affected tenements, and compared the results of my inquiry with a book which was kept by the burgh authorities, containing the results of a house-to-house visitation. This visitation was ordered by Dr. Littlejohn, of Edinburgh, who was sent by the Board of Supervision to inquire into the facts of the epidemic. His report was published, and may be found in the volume of Health Reports issued by that body. There were three houses, in flats one above the other, on each side of the common stair. The three houses on the left side of the common stair drained into a common soil-pipe, which was conducted through the centre of these houses, and got exit at the basement flat into the drain and cesspool described by Dr. Fergus. There was no proper ventilation in this soil-pipe.

Family No. 1, on the ground flat, consisted of four adults and three children. Their wash-house had a bell-trap leading directly into the drain. The cover of this bell-trap had been removed, so that there was an open communication between this house and the cesspool. The milk supply was not got from the tainted source, and there was no fever in this family.

Family No. 2, on the second flat, consisted of five adults and five children. The case of these people exemplifies the kind of fallacies which occur in the returns of an official inspection by the ordinary sanitary officer. They were reported to be free from fever, and to get no milk from the Eaglesham dairy. On personal inquiry, I was told by the lady of the house that two of her children were ill for six weeks with feverishness and diarrhœa, and that her servant had been confined to bed for a fortnight with a very severe feverish illness. The doctor in attendance refused to name the disease, or to allow her to certify the cases as fever to the sanitary officer. She learned afterwards that he told her relatives that the children were suffering from the fever. Her entire milk supply was got from one of the tainted dairies, until her husband, who was a Magistrate of the burgh, caused her to change to another dairy, because he had become acquainted with the dangerous nature of his former milk supply. The house-to-house visitation did not begin until after the milk supply had been changed, and so, in the burgh reports of this family there is no record of the fever, and an erroneous statement about the milk supply. In this way Dr. Littlejohn's returns were rendered very inaccurate.

Family No. 3, in the topmost flat, consisted of four adults and three children. They got their ordinary milk supply from a pure source, but they occasionally got a little milk from the tainted source. The lady of the house informed me that this milk was used for making puddings, and always boiled. This family did not suffer from fever.

On the right-hand side of the stair there were likewise three houses, having a common soil-pipe, draining into a cesspool. There were two wash-houses on the basement flat, with bell traps, the covers of which had been removed, so that here also there was an open communication with the drain and cesspool. The family on the ground flat consisted of four adults and six children. They got their milk from the tainted source. Five of the children had typhoid fever. The house on the second flat was not occupied at the time of the epidemic. The family on the top flat consisted of three adults and seven children. They got a considerable supply of milk from the tainted source. Two of them had fever. I will not weary you by going over in detail the individual cases in the other tenements. I may sum up the result of my inquiries thus:—In every case of fever which occurred in Royal Crescent the patient was ascertained to have swallowed the tainted milk.

Eighty-four persons lived in Royal Crescent who were found to have got their milk supply from pure sources. No case of fever happened among these 84 people, although they were exposed to the emanations from the cesspools, containing the mass of decomposing typhoid excreta so graphically described by Dr. Ferguson. In four of the tenements of Royal Crescent these cesspools remained unaltered until the 25th of August, and the typhoid excreta floating in them were allowed quietly to decompose and evolve their noxious gases into the soil-pipes of their respective tenements; yet the fever disappeared quite as speedily from these houses as from those in the house drains of which these laboratories for the manufacture of sewage gas were replaced by properly-constructed water-traps. When we trace the course of sewer No. 2, we find that the typhoid discharges from Royal Crescent were carried through the village of Strathbungo, which drained into this sewer. This village had an estimated population of 2400. Only one case of typhoid was known in Strathbungo at that time, and it was ascertained that that unfortunate patient, who died of the disease, had got her milk supply from the tainted source in Crosshill. The effect of the emanations from sewer No. 2 on these 2400 people was *nil.* One other illustration, and I am done with the Crosshill epidemic.

Typhoid fever occurred in seven families in the neighbouring suburb of Langside. Every one of these families got their milk supply from the tainted source. The drainage of Langside is quite unconnected with that of Crosshill, and runs in an opposite direction. Some of these families had separate drains for their own houses. But a few cases happened along the course of a common sewer which drained all the houses on the western slope of the hill on which Langside is situated. On the highest part of the hill, and draining into this sewer, there stands an old residence, part of which was built 200 years ago. Two years ago the proprietor of this house asked me to give him some advice about the drainage, as, although he had renewed the whole of the plumber work a short time previously, and spared no expense in obtaining the arrangements which the plumber believed to be the best for preventing the admission of sewer gas, still he was annoyed by disagreeable smells, and said he always felt out of sorts when he remained long in that house without a change. I told him that, in the case of a house 200 years old, there were very likely some old forgotten drains leading to the common sewer, and advised that a trench should be dug all round the house, as deep as the foundations, so that any such drains issuing from it might be discovered and filled up. By these means we did discover five open channels under the floor of the oldest part of the house, leading directly into an old drain. This old drain communicated with the house drain, a few yards on the sewer side of the water-trap, which was supposed to cut this house off from sewer gases. There were in this way five open channels by which rats and sewer gas were admitted freely under the floor of a house standing on the summit of a hill, and connected with a sewer which received the discharges of at least 30 families lower down. At the time of the Crosshill epidemic, five cases of typhoid fever occurred among those families whose discharges were carried into this sewer, and at various times, during the fourteen years of my residence in Crosshill, I have attended numbers of cases of measles and scarlet fever, and I have known of several cases of diphtheria among these people. From the year 1856 till 1873 this old residence was occupied by a family, consisting of father, mother, five children, and three domestics. The domestics were, of course, changed occasionally, so that a considerable number of domestics must have been habitually breathing the gases from this sewer during these seventeen years. On making inquiry as to the family health, I was informed that for the first twelve years they had no illness of any kind. Then in 1868 the eldest daughter died from the effects of a surgical operation. In the summer of 1869 two of the children had typhoid fever. I was informed that that was a very dry summer, and the Gorbals gravitation water, with which the house was supplied, had a very offensive smell, and was infested by large numbers of insects. The doctor in attendance on the family decided that these children had been poisoned by this offensive water. From that time till they left the house, in 1873, this family did not suffer from serious illness of any kind. Although another family occupied that house from 1874 till last year, and were exposed to the same extraordinary invasion of sewer gases during the time of the Crosshill epidemic, and until the old drains above described were discovered and filled up, no member of that second family, and no domestic in that house, suffered from any form of infectious disease.

If any further proof is needed of the erroneous nature of the popular sewage gas theory of the propagation of typhoid fever, it may be found in the published records of the numerous epidemics which have been traced to tainted milk since I published my first observations on this subject. Every epidemic which has occurred in Glasgow during the past five years has been traced to this cause. In former times these epidemics would undoubtedly have been ascribed to sewer gas, admitted by the well-known defects of our soil-pipes and house drains. In a paper published in 18[illegible]9, Dr. Fergus says of Glasgow, "So far as I can remember, I have never yet inspected a house where I found the soil-pipes and drains in a satisfactory condition." In another place he states that, even if it were shown that the drains and soil-pipes of our houses were perfect, sewer gases find their way back through perfect water-traps. In a still more conclusive and striking manner, our respected member Mr. Buchan has proven the alarming extent to which the inhabitants of Glasgow are exposed to this supposed cause of typhoid fever. Lately, in conversation with him on this subject, he informed me that he had examined by the smoke-test 200 houses in the west-end of Glasgow, and that the smoke issued

m some perforation or crack, or crevice, inside the house, in
) cases; showing that, with one exception, the atmosphere of
ry house was being contaminated by sewage gases from the
se drain. Further, 10 per cent. of these houses had no trap of
r description upon the house drain, so that there was a free
mmunication between the house and the public sewer.

Bearing these facts in mind, let us take the records of two of the
sgow epidemics, which were traced to a tainted milk supply,
l published by Dr. Russell, at the request of the Health Com-
ttee of the Town Council. We will take first the Washington
eet outbreak, which occurred in the autumn of 1875. At page
f this Report we find the following statement of the very
iking manner in which the fever was confined to those who
took of milk which was proven to have been tainted by typhoid
reta:—In Washington Street, Bishop Street, Main Street, and
bcross Street, among 483 persons who got their milk supply
ly or occasionally from the tainted dairy, there occurred 58
es of undoubted typhoid and 30 cases of a feverish illness, suspi-
sly like typhoid, while among 579 individuals, with a different
k supply, living in the same streets and tenements, having the
e drains and sewers, and being exposed to the emanations from
typhoid excreta of these 60 or 80 cases, only one case of the
r could be discovered.

he only other epidemic which I shall refer to in this connection
rred in the west-end of Glasgow in December, 1877, and the
wing January of 1878. Cases of fever occurred in the follow
localities:—Hill Street, Berkeley Terrace, Royal Terrace,
edoch Crescent, Park Street (East), Park Circus, Park Gardens,
k Quadrant, Park Terrace Lane, West-End Park Street, Wood-
s Terrace, Claremont Terrace, Woodside Crescent, Newton
e, and Bath Street. 122 families, living in the streets and
aces named, had their milk supply, either wholly or partially,
n dairies which were proven to have given out a milk tainted
h the excreta of typhoid fever patients. Of these, 29 families
e affected with fever. 675 families, living in the same streets
terraces, were supplied with milk from other sources, and of
e only one family was discovered to have fever. Here we have
onous excreta introduced into the house drains and sewers of
localities, the soil-pipes and drains of which are proven to be
remely imperfect by the published statements of such competent
horities as Dr. Fergus and Mr. Buchan; and yet, with the

exception of one family in Bath Street, these 799 families continued for several weeks to be exposed to the emations from these poison-ladened drains and sewers, without any evil result which could be proven.

Although I think the evidence which I have brought before you to-night is sufficient to warrant me in saying that no extensive epidemic of this fever can be propagated by the inhalation of the air which is carried back into our houses from the sewers, yet I think it quite likely that particles of matter containing disease germs do occasionally get into our houses through this agency. In consequence of the rise and fall of the sewage leaving the sides of the sewer alternately wet and dry, particles of typhoid excreta, or other disease products, may occasionally get dried on its sides, and be carried back into our houses in the form of dust, where there is no intervening water-trap to stop its progress. Of course, the same thing may happen in a common soil-pipe or house drain. In this way, a few particles may gain admission through an untrapped house drain or a perforated soil-pipe. But even if these particles are inhaled by a susceptible individual, I do not think it likely that they will be absorbed in such a way as to produce the fever, unless they are actually swallowed into the stomach with the saliva or the mucus of the nostrils. I believe, in fact, that the poison of typhoid fever must be swallowed, if it is to germinate in the body. That this fever is occasionally contracted by the inhalation and subsequent swallowing of dust particles of typhoid excreta, I firmly believe. In a sewer which is constantly being deluged with water, the chance of dust particles of human excreta being allowed to form is very small, as compared with the danger from the same excreta in a midden or privy. The records of the epidemics I have just described show that cases of typhoid fever arising from the inhalation of sewer dust must be very rare.

It is often stated that free ventilation renders the emanations from sewers innocuous, but, if the views I have just stated are well founded, there is quite as much danger in breathing the particles in the air exhaled from a street ventilator as in breathing the same particles in soil-pipe air. No amount of surrounding air can, at once, make any chemical change in a dry particle [illegible] infective matter. Statistics prove that ventilation of the sewers of a town does not necessarily diminish the death-rate from typhoid fever. The following Table indicates the average published by Mr. Baldwin Latham, which illustrates this point. I have added a five years' average of the typhoid fever death-rate for Glasgow and Dublin :—

	Average Rate per 1000.
1. Bristol, with no ventilation of house drains or sewers, . .	·38
2. Plymouth, one ventilator on every five miles of sewer, and no house drain ventilation, ...	·36
3. London, where the sewers are ventilated, but the house drains are for the most part unventilated, . . .	·28
4. Croydon, where both public sewers and house drains are ventilated, ...	·59
5. Glasgow, sewers well ventilated, house drains, for the most part, ventilated, ...	·37
6. Dublin, where there are comparatively few water-closets, .	·5

It therefore comes to be a serious question whether we may not err in making an unnecessarily large number of openings on our sewers and house drains. By so doing we may dry up a larger amount of the dangerous material, and promote its dissemination in dust particles.

The only other epidemic disease common in this country, which recent investigation connects with the exhalations from human excreta and sewer gases, is diphtheria; all the observations which I have made in the case of typhoid fever apply with even greater force here. We do not know what the essential poison of diphtheria is, and we cannot say that it certainly exists in the alvine discharges of the diphtheritic patient. Experiment rather goes to show that in this disease the poisonous matter is confined to the discharges from the throat, and that it is only disseminated by direct contact with particles of the diphtheritic exudation coughed out by the patient. It is possible that a certain amount of this isonous matter may be swallowed by the patient, and if we cede—what we really know nothing of—that it may pass ough the stomach and intestines without losing its virulent perties, it may in this way gain access to the sewers. But, as ave proven that large quantities of typhoid excreta may exist re without any proven extension of that disease by these nnels, I would infer that these small quantities of diphtheritic tter can do very little harm. By analogy, I would affirm that demics of diphtheria do not arise from sewer exhalations.

I have looked carefully into the statistical evidence which Russell brought before this Society in his paper upon "Filth eases in Town and Country." I am quite satisfied, after careful consideration of this subject for some years, that we have no means of differentiating diphtheria from membranous croup. I have repeatedly known a case, which was at first termed diphtheria, ultimately registered as croup when the child died with croupy symptoms, and cases have been frequently reported in which, although the case was at first supposed to be croup, it was ultimately decided to be diphtheria, when diphtheritic symptoms appeared in another member of the family. I believe that the Registrar-General acts wisely in grouping these diseases under one head. In the small houses of the poor, where the parents do not send for a medical man until the child has shown dangerous symptoms of choking, the case is likely to be registered as croup; whereas, in a larger house, in which the child is seen at an earlier stage of the disease, before the croupy symptoms develop, it is more likely to be termed diphtheria. Then again, a large proportion of the children dying in the poorest houses are not seen by a medical man at all, and every case of diphtheria which ends in croupy symptoms is certain to be registered by these ignorant persons as croup. With all respect for Dr. Russell, I do not think that in the present state of medical knowledge he is warranted in drawing any deduction as to the etiology of diphtheria, as contrasted with the etiology of croup, from the statistics he advances. The conclusion that diphtheria is more prevalent in small houses which have water-closets than it is in those that have none, is based upon a mass of the most untrustworthy returns. Any man who has examined the books of a registrar, and seen the extraordinary declarations there recorded as to causes of death, must look with utter incredulity upon any statement with regard to a differential diagnosis of disease founded upon such a basis. In the closing paragraph of that paper Dr. Russell makes the following statement, and asks a question:—"Even with all the outrageous blunders of position and construction in our largest and best houses, and without that official inspection of new buildings in regard to details of sanitary arrangement which ought to be instituted, you have seen that in these houses, in the four years, 1873-76, the mortality from diphtheria was only 126 per million, and from enteric fever 186—rates which are far below those which constantly prevail in the majority of purely country districts, as depicted on those diagrams, and also much below the mortality from enteric fever in small houses which have no sewer connections whatever. But how do those diseases occur in houses with no sewer connection?" Dr. Russell's

tion—How do those diseases occur in houses with no sewer
ections whatever?—brings me to the second part of my
ect, the sanitary problems of the dry system. In illustration
iese, I shall relate the story of an epidemic of typhoid fever
h I personally investigated. In the autumn of 1875 I learned
two families, to whom I acted as medical adviser, had con-
ed typhoid fever in Millport. As Millport is situated on the
l island of Cumbrae, in an isolated position, it seemed to me
a very promising place for a successful investigation into the
s of these cases. On arriving there, I found that, at that
, all the excreta of the inhabitants were collected on the dry
m in privies and middens behind the houses, and taken by
farmers to manure the fields behind the village. The first
into which I inquired occurred in the Foulpart district, and
affected family drank water from a well, situated on the
h, called the "Tea-well." My suspicion naturally attached to
water of this well, and I had not far to seek for the source of
amination. This Tea-well is an open trough, fed by a pipe
h collects the water from an open surface drain in an adjoining
. At the time of my visit a heap of manure, collected for the
ose of spreading over the field, was lying near the edge of the
ce drain. I learned, on inquiry, that this manure was collected
the privies of a part of Millport, in which typhoid fever had
red every year for some years previously, and it must there-
contain the specific poison of the disease. Every shower of
rained this filth and poison into the well. From the date of
eposit of this manure heap six cases of typhoid had occurred
g the people who drank this water, and also several cases of
rish illness of an indefinite character—probably mild typhoid.
istory of my other Millport patient is equally instructive.
ved in the Glasgow Street district, in which the fever had
iled extensively for several years. The water supply of this
t came from a well sunk in the centre of a large turnip field.
ned that this turnip field was manured with dung collected
the part of Millport which it supplied with water. As the
water was simply the surface drainage of the turnip field, the
e of that neighbourhood were therefore supplied with a filtered
ion of their own excrement. On further inquiry, I learned
a still worse state of matters had existed in Millport. In
, I was informed that 26 cases of typhoid had occurred; in
, 35 cases; in 1874, 60 cases. In the latter year, when

matters were getting so serious, the medical officer of the place noticed that the farmer who cultivated this turnip field had a large accumulation of manure, collected from the privies of Millport, on the top of an earthenware pipe with open uncemented joints which supplied the Glasgow Street district with water. When the water carried through this pipe was analysed, it was found to be loaded with organic matter. After all these facts had been ascertained, and meantime 60 persons poisoned, this manure heap was removed, and the fever disappeared, to break out again in a milder form when the field came to be manured with the excreta of these 60 patients.

There is no doubt that the soil performs a kindly office in concealing from our view these dangerous materials, and that, if you do not over-tax its powers, it may even destroy their poisonous properties; but I am quite convinced that a water supply derived from the surface drainage of fields manured, as these fields were, with the poisonous discharges of typhoid fever patients, is certain to develop periodical outbreaks of that disease. The history of this village points to the great dangers of the dry system of disposal of human excreta. We frequently hear of outbreaks of various forms of zymotic disease in remote pastoral districts, where such diseases may have been unknown for a generation. What happened in Millport may help us to an explanation of such cases. What is more likely than that the disease germs have been carted out from the adjoining town in the manure cart, and by chance shunted down at the side of a water-course or on the top of a well? We know that the manure of Glasgow contains the excreta of one-half of the population, removed from the lowest, and, in a sanitary point of view, the worst parts of the city. This manure often contains in abundance the alvine discharges of typhoid patients. Rags stained and saturated with the contagious expectoration of diphtheria and the sweepings of the houses in which rage scarlet fever and measles. All this heterogeneous mass of poison is carted to the manure heaps in the outskirts of Glasgow, there mixed with other manurial refuse, without the slightest attempt at the separation or disinfection of the dangerous elements, and then transported to the farmers of the dairy districts around Glasgow. I believe that in some of the milk epidemics which I have already spoken of so fully we are being punished for what I can only characterise as the recklessness and ignorance displayed in the dry methods of disposal, as they are at present conducted. We are receiving back with con-pound interest the germs of disease which we have sent out. The cleansing authorities in the towns and villages of this country are as truly dealers in poison as are the traders in arsenic or strychnine, and the dangers of ignorant and careless methods of conducting their business are immensely greater.

We cannot speak too strongly on this subject. Until our parochial and urban rulers, and the farmers themselves, are convinced as to the dangers of using these poisonous materials as manures for fields, the surface drainage of which may pollute their water supply, we cannot hope much to diminish the spread of typhoid fever, 140,000 cases of which occur annually in this country, giving rise yearly to 15,000 deaths and an untold amount of misery. I need not speak of other dangers.

Before closing I shall indicate, very briefly, the bearing which the observations I have recorded in this paper have upon the modifications upon existing methods of disposal, which the last Glasgow Sewage deputation recommend for adoption in this city. At page 5 of the Report they say:—"Whatever may be said in a itary and economical point of view of the various dry systems disposing of excreta—and we freely acknowledge that some of [illegible] arguments in favour of these are unanswerable—we regard ir reintroduction into water-closeted towns as altogether hope[illegible]; and we are the more reconciled to the conveyance of sewage, ctly so called, by water-carriage, since the ordinary house nage, which is almost as offensive and quite as impure, cannot isposed of, in this country at least, in any other way."

While I believe that the water-carriage system is a great sanitary nder when introduced in towns and villages which drain into ams forming the water supply of the population upon their banks; le I hold it to be a dangerous source of disease, and, apart from [illegible] aspect of the question, an utter abomination, to compel the lations on the lower reaches of a river to drink water polluted [illegible] the excrement of towns and villages near its source—yet I k that the water-carriage system as applied to a town like gow, which drains into a tidal river, or to a town situated on sea-coast, where the water supply is pure and protected from amination, is much less dangerous than are the present methods isposal on the dry system. Although I have brought forward lence in this paper which proves to me that epidemic disease is spread to any serious extent by sewer gases, I do not mean to rt that the atmosphere of a house habitually tainted with these gases is harmless. The habitual breathing of an impure atmosphere is one of the surest means of deteriorating the health, and is one of the factors which tends directly to the development of constitutional disease. The various forms of organic degeneration—of which consumption of the lungs may be taken as a type—are the forms of disease which we associate most surely with all the various influences of bad food, impure air, insufficient clothing, and uncleanliness of person. But I do think that, with the adoptio of proper sanitary supervision of our house drains and soil-pipes such as this Sewage Report recommends, the dangers from sewe gases to which our city populations are at present exposed wil become recollections of the past. The adoption of the sewag precipitation scheme will remove the only objection which, as sanitarian, I can urge against the water-closet system in Glasgow

I cannot speak with approval of the dry methods recommended, because, while they adopt a part of the Mancheste pail and tub system, they stop short at what seems to me, looking at the matter from the sanitary point of view, begins the mo important part of this method. They do not recommend fo adoption the chemical and drying processes, which convert th dangerous excreta of diseased neighbourhoods into a valuable an harmless manure. They do not propose to destroy the dangerou contents of ashpits saturated with these excreta, and convert thes valueless and dangerous materials into charcoal, mortar, and Portland cement, as is done more or less completely in 12 towns i England, which have had the enterprise to act as pioneers in thes matters.

In the three forms of apparatus adopted by these towns, not as far as I can ascertain from their reports—for any sanitary reaso but because of their convenience and the money saving which the effect on the former methods of disposal, in the Destructor, Ca boniser, and Concreter, patented by Mr. Fryer, of Nottingham, w have the most perfect means of destroying the germs of zymot disease.

Whether any better system can be devised for Glasgow may b a matter for consideration, but it is clearly the duty of those wh have the arrangement of the new methods of disposal of the excret and refuse from the poorer parts of Glasgow, with all the ligh which has been shed on these matters of late years, and the example of these English towns, to adopt some efficient means of preventing the great dangers of the present manure heaps, which pollute the atmosphere and poison the inhabitants, alike of Glasgow and of the country districts to which they are transported.

XVIII.—*On Vegetable Parasites on the Tea Plant, more especially that of Assam.* By JAMES STIRTON, M.D., F.L.S.

Read before the Society, 27th April, 1881.

MR. A. WATT, a tea planter in Assam, and formerly resident in this city, has favoured me, from time to time during the last three years, with numerous specimens of the bark and leaves of trees and shrubs growing in his neighbourhood. These barks were sent, in the first instance, mainly for the sake of the parasitic lichens and fungi growing, more especially, on the different varieties of the tea plant cultivated there, with the view of ascertaining, if possible, how much the vegetative processes of the plant were interfered with by such invasion. Becoming, however, interested in the subject, Mr. Watt has latterly widened his field of research, and, while his attention is still mainly directed towards the condition of the tea plants, he has sent me corresponding parasites from trees in the jungle or aboriginal vegetation.

As might have been anticipated, there is a marked difference in the parasitic organisms of the two habitats. Those infesting trees and shrubs in the open (or cleared and cultivated land) belong, in much the larger proportion, to the division of lichens, and they mostly affect barks, while a comparatively small number are resident on the upper or exposed surface of leaves. It is noticeable, also, that the hard smooth coriaceous leaves of evergreens are the hosts of such parasites, while those of a deciduous character are seldom attacked.

As a rule, lichens require a much longer time for the development of the stages of the vegetative and reproductive processes than fungi, and do not invade the tissues of the host, inasmuch as they are not dependent for their development on the juices of the plant on which they rest. Not so fungi, which feed on the protoplasm of the plants they attack. It is remarkable, also, that certain tribes of the microscopic fungi (of which we shall mainly treat) are singularly selective, so to speak, of their vegetable victims, and the presumption is that a certain quality of protoplasm is necessary as a pabulum. In this way certain tribes of plants are known to be infested by certain species of fungi—so much so, indeed, that mycologists are, in many cases, content to name the parasitic fungus from the plant host.

Another peculiarity worth noticing is that plants under cultivation are more liable to be attacked by fungi than those in a state of nature, and the higher the degree of cultivation the greater the liability and the more destructive the effects.

The tea plantations of Assam from which cryptogamic plants have been sent are all situated on alluvial soil, a soil which had formerly been submerged, and had formed the upper part of what was at one time the estuary of the river Brahmapootra. This soil is accordingly composed entirely of very fine silt, and not even a pebble can be detected for a depth of many feet beneath the surface.

From such geographical peculiarities two conclusions can readily be deduced—1st, the rainfall must be very considerable and mainly at two seasons of the year; 2nd, the land is one of the most recent geological formations, possibly one within historical times, at any rate within such as are included in Indian or Chinese records. This statement is borne out from the fact that no ruins of any consequence occur within the space included by these tea plantations, although such ruins are plentiful enough higher up on either side, and especially on the west or Ganges side of Assam, at no great distance from the site in question, and indeed forming part of the same vast alluvial basin. As is well known, this basin of India is peculiarly adapted to the cultivation of the tea-plant, and produces some of the best-flavoured samples hitherto introduced into our markets, under the names of Indian and Assam teas; in fact, this basin is to India what that of the Yang-tse-kiang is to China, and, being further south, is more favourably situated, inasmuch as the leaf is more tender, and accordingly yields its peculiar properties more readily, as well as in greater abundance, and of more delicate aroma.

From such conditions of soil and climate it will readily be conceded that vegetation of every sort, phanerogamic as well as cryptogamic, is favoured in an unusual degree. The specimens sent to me prove this unmistakably, inasmuch as they are well developed in almost every instance, and the difficulty of discrimination and determination is less than I have experienced in corresponding plants from any other part of the globe.

During my investigations it soon became evident that, in order to render the results fairly intelligible to the general public, it would be necessary to form two distinct divisions of my subject—the first embracing botanical descriptions of the parasites proper; the second portraying, so far as could be done, the probable effects of such organisms upon the tea plants more especially.

The first part is what I propose at this time to lay before this Society, the second must be deferred until I have received a more extended series of specimens which will show more effectively and continuously the various stages of development and growth of these parasites.

Sphinctrina exilis. Sp. nov.

Thallus pallide cinerascens tenuissimus; apothecia tenella stipitata (altit. ·4 – ·5 mm.), capitulo fusco-nigro vel nigro, breviter cylindraceo-turbinato (latit. ·1 – ·12 mm.), stipite gracilento pallido; sporæ 8næ uniseriatæ, ellipsoideæ fuscæ vel fusco-nigræ, simplices, ·008 – ·011 × ·005 – ·0065 mm.

Corticola: cum *Lecidea fusco-rubella* associata. The thecæ were evident in almost every instance examined.

Tylophoron (Cotylaria) nidulans. Sp. nov.

Thallus pallide glaucescens vel pallide cinereo-plumbeus lævigatus rimuloso-areolatus bene evolutus; apothecia in tuberculis thallinis (latit. ·4 – ·8 mm., altit. circiter ·6 mm.) fere cylindraceis innata, perithecio nigro integro (infra) tenui, massa sporali (supra) nigra concaviuscula vel plana (non protrusula), firma sicut in *Lecanoris*; sporæ incolores dein fuscæ vel fusco-nigræ, ellipsoideæ, 1 – septatæ, ·0075 – ·0095 × ·004 – ·0055 mm. Hymenium rufescens præsertim infra; paraphyses irregulares, granuloso-inspersæ. Iodo gel. hym. non tincta nec sporæ. Corticola.

The differences indicated above between this and the genus Tylophoron, as represented (more especially) by T. protrudens, (Nyl.) are of sufficient significance to warrant a generic distinction; accordingly, it might be as well to give effect to this (meanwhile at least) by constituting a new genus under the title *Cotylaria.*

Tylophoron (Cotylaria) punctiforme. Sp. nov.

Thallus cinerascens tenuis hinc inde rimulosus determinatus; apothecia in papillis thallinis (latit. basi ·2 – ·3 mm.; altit. circiter

·25 mm.) innata, epithecio (latit. ·1 – ·2 mm.), massa sporali nigra, convexula vel plana; sporae simplices fere sphæricæ, fuscæ vel fusco-nigræ, ·007 – ·01 × ·006 – ·0085 mm. Corticola.

The spores, although seldom seen in the thecæ, are uniseriate.

The epithecium shows at first as a minute point—*i.e.*, nearly covered by the thallus—but ultimately it assumes a lecanoroid habit, and, so far, agrees with the preceding.

Physcia endoxantha. Sp. nov.

Thallus stellatus adpressus, cinerascens vel glauco-cinerascens, hinc inde albido-pruinosus (præsertim laciniarum apicibus), conferte et auguste laciniatus, laciniis planis linearibus, subtus nigris et nigro-rhizinosis, intus flavescens vel ochraceus (K sordide purpurascens). Corticola; sterilis.

Thallus supra K flavens et sparsim flavido-korediosus.

Lecanora punicea * accolens.

Similis L. puniceæ (Ach.) sed thallo glaucescente vel virescenti-glaucescente et ambitu albide fibrilloso-radiato. Sporæ (4 – 8)næ, bacillares, 5 – 10 – septatæ, ·045 – ·06 × ·004 – ·0055 mm; apices paraphysum K fugaciter violacei vel purpurascenti-violacei. Corticola.

Phlyctis polyphora. Sp. nov.

Thallus albidus, pallidus vel pallide cinerascens tenuis, nonnih[illegible] pulverulentus (K – C –); apothecia cæsio-albida pruinosa, rotun[illegible] data, oblonga vel interdum anguloso-difformia (latit. ·4 – 1·2 mm.) [illegible] margine thallino prominulo cincta; sporæ (3 – 4 – 6 – 8?)n[illegible] incolores elongato-fusiformes vel oblongo-fusiformes, (16 – 32) [illegible] loculares (loculis mediis interdum hinc inde 1 – 2 – divisis), ·06 [illegible] ·11 × ·0075 – ·0095 mm.; paraphyses distinctæ; hypothecium [illegible] incolor vel lutescens. Iodo gel. hym. non tincta nec spor[illegible] Corticola.

Thelotrema exalbidum. Sp. nov.

Thallus albidus vel pallide cinerascens interdum nonnihil [illegible] farinaceus; apothecia in prominentiis exsertis (latit. basi circit[illegible] 1 mm.) immersa, pallida, ostiolis firmis rotundis vel elliptici[illegible] (latit. ·2 – ·4 et etiam ·5 mm.), epithecio vulgo albo-suffuso, margine proprio a thallino libero, fere integro et nonnihil connivente; sporæ 8næ fuscæ et nigricantes, obovatæ (*i.e.*, uno apice acutiusculæ), 6 – 9 – loculares (loculis mediis interdum semel divisis), ·045 – ·07 × ·009 – ·013 mm.; paraphyses graciles, distinctæ, confertæ. Iodo gel. hym. non tincta nec sporæ. Corticola.

Arcte affine *Th. pachysporo* sed differens margine proprio, sporis, reactione chemica, &c.

Ascidium tetrasporum. Sp. nov.

Thallus pallidus vel sordide virescens, laevigatus, nigro-limitatus, interdum rugulosus vel tuberculosus; apothecia in protuberantiis thallinis hemisphærico-conicis (latit. 1 – 1·8 mm.) inclusa, perithecio globoso, integre nigro tenui; sporæ 4næ incolores, cylindraceo-oblongæ, sæpe curvulae, murali-divisæ, ·16 – ·25 × ·24 – ·032 mm.; paraphyses filiformes, longæ, granulis et guttulis oleosis creberriter inspersæ. Iodo gel. hym. non tincta, protoplasma thecarum vinose rubescens vel interdum vinose rubens. Corticola.

In every instance where the thecæ were entire 4 spores were present.

Lecidea inornata. Sp. nov.

Thallus obscure cinerascens vel cervinus granulato-areolatus, hinc inde rimulosus, ambitum versus sæpe concentrice zonatus et yssino-radiatus (K fl. dein intense rubens); apothecia nigra ncaviuscula vel plana, obtuse marginata demum convexula et e immarginata; sporæ 8 næ in thecis saccatis, oblongo-ellipsoideæ, cæ 1, – septatæ, ·013 – ·018 × ·006 – ·0075 mm.; paraphyses ciles discretæ filiformes apicibus fuscis clavatulis; hypothecium lide fuscum. Iodo gel. hym. cærulescens dein sordida.

Graphis colligata. Sp. nov.

Thallus macula pallescente vel pallido-lutescente, nitidiuscula icatus; apothecia in prominulis thalloideis pallidis depressis ut in *Glyphide labyrinthica,* oblongis vel nonnihil irregularibus it. 4 - 20 mm.) innata, minuta conferta, tortuosa interdum ssi moniliata vel constrictiuscula, primum thallino-velata dein mpentia demum explanata, disco fuscescente concaviusculo vel niusculo (latit. ·08 – ·14 mm.), margine thallino circumscisso presso cincta; sporæ 8næ fuscescentes oblongæ 4 – loculares, raro 6 – loculares, ·018 – ·024 × ·007 – ·009 mm.; paraphyses diocres, granuloso-inspersæ; hypothecium incolor. Iodo gel. ym. pallide rufescens vel non tincta. Corticola.

Graphis intortula. Sp. nov

Thallus pallide cinereo-plumbeus tenuis nitidus (K. fl. dein intense ferrugineo-rubens); apothecia concoloria vel pallidiora, innata, conferta, elongata et valde tortuosa, margine thallino latiusculo prominulo, (1-3)-striato cincta, epithecio rimiformi; sporæ 8næ incolores, ellipsoideæ vel fusiformi-ellipsoideæ, 4-loculares (loculis mediis semel divisis), ·012 – ·014 × ·005 – ·0065 mm.; paraphyses distinctæ; hypothecium incolor. Iodo gel. hym. leviter, interdum obsolete cærulescens. Corticola.

Graphis implexula. Sp. nov.

Thallus macula pallide cervina vel luteo-rufescente, nitida indicatus; apothecia minutissima in maculis pallidioribus nonnihil farinaceis congregata, oblonga, linearia vix ramosula, obtusula, epithecio rufescente plano (latit. circ. .05 mm.) immarginato sed margine pallido thalloideo depresso cincta; sporæ 8næ uniseriatæ, incolores, ellipsoideæ vel oblongo-ellipsoideæ, 4-loculares (vetustæ fuscescentes), ·012 – ·014 × ·007 – ·008 mm.; paraphyses distinctæ filiformes, longiusculæ; hypothecium incolor. Iodo gel. hym. non tincta. Corticola.

Graphis cirrhata. Sp. nov.

Thallus sordide pallescens, nitidus, tenuis; apothecia conferta, albida farinacea, innata, linearia, tortuosa, epithecio rimiformi et prominule thallino-marginato; sporæ (4 – 8) næ incolores dein fuscescentes, 5-8-loculares (loculis præsertim mediis semel, rarius bis divisis), ellipsoideæ vel oblongo-ellipsoideæ, ·02 – ·027 × ·011 – ·013 mm.; paraphyses distinctæ graciles, filiformes in gelatina firma involutæ; hypothecium incolor vel lutescens. Iodo gel. hym. non tincta, sporæ leviter infuscatæ. Corticola.

Graphis firmula. Sp. nov.

Thallus pallescens vel pallide lutescens, lævigatus firmus determinatus; apothecia innata primum fere occlusa, demum erumpentia, oblonga flexuosa et ramosa, sæpe radiatim disposita, epithecio primum coarctato dein canaliculato vel planiusculo (et tunc latit. ·2 mm.) albido-pruinoso, margine thallino prominulo, crassiusculo nonnihil irregulari, perithecio fusco vel fusco-nigno tenui laterali; sporæ 8 næ fuscæ oblongæ, 5 – 8-loculares (loculis mediis sæpe semel divisis), ·022 – ·032 × ·007 – ·01 mm.; paraphyses irregulares; hypothecium incolor. Iodo gel. hym. non tincta. Corticola.

Graphis extrusa. Sp. nov.

Thallus macula pallescente, pallide lutescente, interdum pallide luteo-virescente nitida indicatus; apothecia exserta, elongata, tortuosa et ramosa, obtusa, epithecio fusco planiusculo vix marginato (latit. ·2 – ·3 mm.), perithecio integro tenui fuscescente hinc inde vix visibili; sporæ 8næ fuscescentes oblongæ vel nonnihil obovatæ, 8 - loculares, rarissime 7 - loculares, ·027 – ·038 x ·009 – ·013 mm.; paraphyses distinctæ firmæ rectæ apicibus rufescentes, inspersulæ; hypothecium rufescens tenue. Iodo gel. hym. non tincta, sporæ infuscatæ. Corticola.

The apothecia are situated on raised thalline lines such as in Graphis exserta (Nyl.). It seems allied to Gr. Lyellii (Sm.).

Graphis extrusula. Sp. nov.

Similis præcedenti sed sporis 5 – 6 – locularibus et ·018 – ·027 x ·006 – ·0075 mm. Epithecium angustius (latit. ·15 – ·25 mm.).

The differences indicated are constant and no intermediate states have been detected. The perithecium is thinner, and at times scarcely perceptible as a thin rufescent line; while the apices of the paraphyses are nearly colourless; and the hypothecium scarcely tinted. Corticola.

Graphis spilota. Sp. nov.

Thallus albidus vel pallescens tenuis nonnihil farinaceus (K flavens dein rubens); apothecia minuta, innata, fusco-rufa vel fusco-nigra concaviuscula vel planiuscula immarginata (latit. ·15 - ·17 mm.), rotundata, oblonga vel elongata et tortuosa et tunc quasi moniliformi-juncta, rarius ramosula; thecæ monosporæ, sporæ incolores vel lutescentes, oblongo-ellipsoideæ, murali-divisæ, ·085 – ·13 x ·028 – ·034 mm.; paraphyses gracillimæ in gelatina firma involutæ; hypothecium incolor vel fere incolor. Iodo gel. hym. leviter vel obsolete cærulescens. Thecæ arthonioideæ. Corticola.

K renders the paraphyses distinct as very fine threads, such as are seen in one or two of the Glyphides.

Graphis discoides. Sp. nov.

Thallus albus vel albidus tenuis farinaceus (K – C –); apothecia innata rotundata vel nonnihil oblonga fuscula vel fere incoloria cæsio-pruinosa, planiuscula (latit. circiter ·4 mm.), margine thallino prominulo rugosulo cincta; thecæ 2 – sporæ interdum monosporæ, sporæ incolores vel leviter lutescentes, ellipsoideæ murali-divisæ, ·03 - ·04 × ·01 – ·018 mm.; majores, ·054 × ·022 mm.; paraphyses breves crassiusculæ, conglutinatæ sed distinctæ; hypothecium incolor vel leviter lutescens. Iodo gel. hym. non tincta, protoplasma thecarum rufescens vel vix tinctum. Corticola.

Arthonia collectiva. Sp. nov.

Thallus obscure cinerascens tenuis continuus determinatus; apothecia nigra vel fusco-nigra prominula, convexa et immaginata, rugosula, mediocria (latit. circ. ·4 mm.), rotundata, oblonga vel irregularia, sæpe aggregata, intus pallide fuscescentia (K –); sporæ (4 – 6 - 8?)næ nigrescentes, ellipsoideæ, medio constrictæ, 1 – septatæ, ·015 – ·02 × ·008 – ·01 mm.; paraphyses non distinctæ, epithecium fuscum conglutinatum; hypothecium incolor. Iodo gel. hym. non tincta vel interdum leviter rufescens. Corticola.

Arthonia translucens. Sp. nov.

Thallus pallidus tenuis; apothecia rotunda prominula (praesertim madefacta) pallescentia vel lutescentia, pellucida, convexa, interdum thallino-marginata, intus incoloria; sporæ 8næ incolores obovatæ (*i.e.*, uno apice acutiusculæ), 5 – loculares vel 4 – septatæ (loculo superiore admodum ampliore), raro 4 – loculares, ·017 – ·22 × ·0065 - ·009 mm. Iodo gel. hym. vinose violacea (præsertim ea thecarum vacuarum), præcedente cærulescentia obsoleta vel nulla. Corticola.

Arthonia arctata. Sp. nov.

Thallus macula pallida vel sordide pallida indicatus; apothecia nigra rotunda innata plana depressa tenuia (latit. ·2 – ·35 mm.) intus sordide pallida; sporæ (6 – 8) næ incolores dein fuscescentes oblongæ sed medio angustiores et uno apice latiores, 4 – 6 - loculares (loculis mediis angustis, apicalibus multo amplioribus), ·022 - ·03 × ·0085 - ·011 mm.; paraphyses nullæ; hypothecium concolor. Iodo gel. hym. non tincta vel passim obsolete cærulescens. Corticola.

The spores are somewhat dumb-bell shaped, with, however, one extremity more expanded than the other.

Arthonia nemoralis. Sp. nov.

Thallus pallidus tenuissimus nigro-limitatus; apothecia nigra vel fusco-nigra innata, rotundata vel oblonga vel nonnihil difformia depressa (latit. ·5 – 2 mm.), intus obscura vel obscure fuscescentia; sporæ 8næ in thecis oblongo-sphæroideis, oblongæ, sæpissime curvulæ, nigrescentes, medio muralidivisæ loculis apicalibus (superioribus et inferioribus) amplis simplicibus—*i.e.*, non muralidivisis, ·04 – ·06 × ·015 - ·02 mm.; hypothecium concolor. Iodo gel. hym. vinose rubens. Corticola.

Affinis *A. bessali* (Nyl.) sed distincta.

The terminal spaces in the mature spore are quite uniform and not muriform; but occasionally their contents, in the older spores, are partially broken up into largish globules, although not muriform.

Glyphis maculosa. Sp. nov.

Thallus macula pallide olivacea indeterminata indicatus; apothecia in stromatibus albis (K. flaventibus) vel albidis depressis rotundato-difformibus (longit. sæpe 9 mm.) insidentia, nigra conferta, minuta, rotunda vel oblonga et plerumque seriatim disposita, epithecio concaviusculo, intus obscura; sporæ 8næ incolores dein fuscescentes oblongæ, 4 – 6 – loculares, ·02 – ·028 × ·0065 – ·0065 – ·0085 mm.; paraphyses graciles non bene discretæ, confertim granuloso-inspersæ; hypothecium fuscum vel fusco-nigrum. Iodo gel. hym. non tincta nisi lutescens, sporæ vix vel leviter obscuratæ. Corticola.

Arcte affinis *Gl. labyrinthicæ* sed apothecia segregata et stroma album, ubique perspicuum.

Glyphis duriuscula. Sp. nov.

Thallus macula pallido-flavescente nitida indicatus; apothecia in stromatibus prominulis nigris corbonaceis duriusculis, supra hinc inde cæsio-pruinosis oblongis vel difformibus (latit. 2 – 6 mm.) sita, conferta, linearia, flexuosa tenuia (latit. circ. ·1 mm.), acute marginata, epithecio depresso rimiformi; sporæ 8næ in thecis saccatis, incolores oblongo-ellipsoideæ vel sæpius obovatæ et uno apice acutiusculæ, iodo cærulescentes, 6 – 10 – loculares, ·026 – ·045 × ·007 – ·01 mm.; paraphyses filiformes in gelatina firma percurrentes apicibus incoloribus clavatulis; hypothecium nigrum. Iodo gel. hym. non tincta. Corticola.

The paraphyses appear as tubes, but when K. is added they are revealed as distinct filiform threads. This should be separated from all forms of *Gl. cicatricosa*, &c.

Chiodecton punctulatum. Sp. nov.

Thallus cinerascenti-fuscus vel luridus minute granulosus, madefactus punctis perminutis (sub lente visis) albis creberrime adspersus; apothecia (3 – 16) in verrucis thallinis albidis prominentibus parvulis immersa, nigra minuta (latit. circiter ·08 mm.); sporæ (4 - 8)næ incolores obtuse bacillares, 3 – 7 – septatæ, ·03 – ·05 × ·004 - ·005 mm.; paraphyses irregulares sed distinctæ; hypothecium fuscum. Iodo gel. hym. obsolete cærulescens dein vinose rubescens vel etiam vinose rubens. Corticola.

Verrucaria anoptella. Sp. nov.

Thallus pallide flavescens vel pallide cinereo-flavescens tenuissimus; apothecia in verrucis thallinis prominulis magnis (latit. basi circiter 1·5 mm.) inclusa et omnino obtecta, ostiolo fusco demum aperto, perithecio integre nigro vel fusco-nigro tenuiusculo, globoso; sporæ 8næ in thecis oblongis (longit. usque ad ·45 mm.) parietibus crassis hyalinis, incolores oblongæ vel sæpius obtuse fusiformes et crescenticae murali-divisæ, ·13 – ·18 × ·028 – ·036 mm.; paraphyses longæ gracillimæ, granulis et guttulis oleosis creberriter inspersæ. Iodo protoplasma thecarum sæpe vinose fulvescens. Corticola.

The spores appear bilocular as well as murali-locular, and they easily break across in the middle.

Allied to *V. Thwaitesii* (Leight.), but the apothecia are entirely covered by the thallus, and there are no indications of septa, &c.

Verrucaria Assamiensis. Sp. nov.

Thallus macula pallescente vel hinc inde pallide virescente in[illegible]catus; apothecia nigra prominula obtuse conica (latit. basi ·5 – [illegible] mm.) perithecio integre nigro, crasso carbonaceo; sporæ 4 næ interdum (2 – 3)næ fuscæ, elongato-ellipsoideæ vel fusiformi-ellipsoideæ murali-divisæ et insuper 5 - 9 – septatæ, ·055 – ·095 × ·02 – ·03[illegible] mm.; paraphyses confertæ longæ gracillimæ. Iodo gel. hym. vinose rubescens vel vinose rubens.

Ad corticem Theæ.

The apothecia are seen occasionally to be nearly confluent—*i.e.*, the black perithecia blending into one another—but not in such a manner as in Trypethelium.

This lichen seems allied to *V. Borbonica* (Nyl.).

Verrucaria anoista. Sp. nov.

Thallus pallidus vel livido-pallidus nonnihil farinaceus tenuis; apothecia nigra prominula primum thallino-velata dein fere nuda (latit. circ. ·4 mm.), perithecio globoso incurvo, fere integre nigro; sporæ in thecis oblongis (parietibus crassulis hyalinis) 8 næ incolores ellipsoideæ vel oblongo-ellipsoideæ, murali-divisæ, iodo cærulee tinctæ vel cæruleo-infuscatæ, ·04 – ·055 × ·016 – ·02 mm.; paraphyses graciles distinctæ molliusculæ. Iodo protoplasma thecarum vinose rubescens. Corticola.

Verrucaria pustulosa. Sp. nov.

Thallus albus vel albidus nonnihil farinaceus tenuissimus; apothecia hemisphærica, dimidiatim nigra prominula mediocria (latit. ·2 – ·3 mm.); sporæ 8næ incolores oblongo-fusiformes (uno apice acutiores), 6 – loculares interdum 4 – 7 – loculares (loculis subquadratis et mediis interdum semel divisis), ·015 – ·021 × ·0045 — ·006 mm.; paraphyses parcæ distinctæ granuloso-inspersæ. Iodo gel. hym. non tincta, protoplasma thecarum rubescens. Corticola.

Verrucaria introducta. Sp. nov.

Thallus macula nitida, lutescente vel virescenti-lutescente indi[illegible]; apothecia nigra nitida prominula nuda vel basi vix thallino-tecta, perithecio integre nigro crasso globoso (latit. ·5 – ·8 mm.); sporæ 8 næ incolores dein fuscæ ellipsoideæ, 4 – loculares et insuper rarissime 3 – septatæ, loculis obtuse quadrangulis, ·038 – ·05 × [illegible] — ·018 mm.; paraphyses longæ filiformes granuloso-inspersæ. Iodo gel. hym. non tincta. Corticola.

[illegible] cannot identify this lichen with either *V. subducta* var. *retracta* [illegible]) or V. *marginata* var. *convexa* (Nyl.).

Verrucaria immissa. Sp. nov.

Thallus lurido-lutescens vel pallide fulvescens nitidus tenuis; apothecia in protuberantiis thallinis supra fuscis vel fusco-nigris omnino immersa, perithecio fusco-nigro vel tantum fusco, infra [illegible]usculo dimidiato; sporæ 8næ fuscescentes vel fuscæ oblongo-ellipsoideæ, 4 - loculares, ·03 - ·042 × ·013 - ·017 mm.; paraphyses distinctæ filiformes longæ creberrime granuloso-inspersæ. Iodo gel. hym. non tincta. Corticola.

Verrucaria nodulata. Sp. nov.

Thallus flavescens vel virescenti-flavescens, tenuis, nitidus; apothecia nigra prominula basi obtecta, supra nuda (latit. circ. ·4 mm.), perithecio dimidiatim nigro; sporæ 8næ incolores dein fuscæ, ellipsoideæ, utroque apice apiculatæ vel papillulatæ, 4 - loculares (loculis sphæricis et mediis multo majoribus), ·02 - ·027 × ·01 - ·014 mm.; paraphyses filiformes longæ granuloso-inspersæ. Iodo. gel. hym. non tincta. Corticola.

Seems allied to *V. approximans* (Krph.), but there are important differences.

Verrucaria scutata. Sp. nov.

Thallus pallide lutescens vel lutescens lævigatus tenuissimus; apothecia nigra, supra nuda parum prominula (latit. ·3 - ·6 mm.), perithecio duplici, exteriore late dispanso et depresso, interiore globoso integre nigro tenui; sporæ 8næ fuscæ 3 - septatæ, sæpe 4 - nucleatæ, interdum solum 3-septatæ, ·014 - ·018 × ·005 - ·0065 mm.; paraphyses graciles non confertæ. Corticola

Verrucaria concamerata. Sp. nov.

Thallus pallescens vix ullus visibilis; apothecia nigra mediocria (latit. circ. ·4mm.), perithecio duplici, exteriore expanso et depresso, interiore nigro globoso tenui, integro vel fere integro; sporæ 8næ incolores oblongo-fusiformes medio nonnihil constrictæ, 1 - septatæ, ·018 - ·024 × .086 - ·002 mm.; paraphyses distinctæ filiformes ramosæ et interdum intricate contextæ. Iodo gel. hym. rubescens praesertim thecæ. Corticola.

Affinis *V. insulatæ* (Fée).

Verrucaria (Endococcus ?) deportata. Sp. nov.

Thallus macula pallida tenui indicatus; apothecia nigra prominula nitida nuda parva (latit. ·12 - ·2 mm.), ostiolo umbilicato-depresso, perithecio integro; sporæ 8næ uniseriatæ fuscæ breviter oblongæ 1 - septatæ, ·005 - ·008 × ·0035 - ·0045 mm.; paraphyses nullæ. Iodo gel. hym. non tincta. Corticola.

There is abundance of thecæ containing fuscous spores.

Trypethelium indutum. Sp. nov.

Thallus pallide lutescens lævigatus continuus tenuis determinatus; apothecia (1 – 5 vel plura) in stromatibus nigricantibus, primum a thallo obtectis dein erumpentibus, prominulis immersa, perithecio tenui integre nigro, plerumque ampullaceo, ostiolo minuto punctiformi pallido vel pallide fuscescente; sporæ 8næ incolores oblongo-fusiformes apice acutiusculæ vel nonnihil attenuatæ, (12 – 18) - loculares, loculis mediis interdum semel divisis, ·07 — ·11 × ·015 — ·018 mm.; paraphyses graciles filiformes distinctæ. Iodo protoplasma thecarum interdum fulvescens. Corticola.

Trypethelium assimile. Sp. nov.

Simile *Tr. Sprengelii* (Ach.) sed thallus pallide et sordide violaceus K. purpurascens. Sporæ 8næ incolores fusiformes (8 – 14) – loculares, ·034 – ·048 × ·008 – ·01 mm. Corticola.

Trypethelium celatum. Sp. nov.

Thallus pallide flavescens vel pallide virescenti-flavescens lævigatus, crassiusculus (crassit, circ. ·15 mm.); apothecia 2 – 6 in stromatibus nigris in thallo omnino immersis insidentia et primum ab epithallo velata, demum, quoad ostiola nigra punctiformia planiuscula, erumpentia; sporæ 8næ incolores oblongæ 4 - loculares, ·017 – ·023 × ·007 – ·0085 mm.; paraphyses crassiusculæ distinctæ parcæ. Iodo protoplasma thecarum præsertim juniorum vinose rubescens, cæteroquin gel. hym. non tincta. Corticola.

Affine, ut videtur, Tr. erumpenti (Fée).

Melanotheca coactella. Sp. nov.

Thallus macula pallide cinerascente effusa indicatus; apothecia verrucarioidea nigra arcte (2 – 7) - aggregata, minuta (latit. vix ·1 mm.), glomerulos trypethelioideos nigros parvulos (latit. circ. ·4 mm.), rotundatos vulgo formantia, perithecio dimidiatim nigro, sporæ 8næ incolores vetustæ fuscescentes, fusiformi-oblongæ medio nonnihil constrictæ, 1 - septatæ, ·015 - ·021 × ·0045 - ·006 mm.; paraphyses nullæ. Iodo gel. hym. non tincta, protoplasma thecarum rubescens. Corticola.

The apothecia are occasionally seen solitary, although even then there are indications of the presence of a general stroma.

XIX.—*On the Genus Alveolites, Amplexus, and Zaphrentis, from the Carboniferous System of Scotland.* By JAMES THOMSON, F.G.S., Corresponding Member of the Royal Society of Science of Liège, and Honorary Member of the Royal Ducal Society of Jena.

[Read before the Society on 27th April, 1881.]

TOWARDS the end of 1876 I read a short communication before the Geological Society of Glasgow, entitled "Notes on the Genus Alveolites," and stated that, from the examination of a large series of specimens from all parts of the country, I felt persuaded that in the carboniferous rocks of Scotland we not only had represented the two species *Alveolites septosa* and *Alv. depressa*, Milne-Edwards and Haime, as described in their admirable memoir to the Palæontological Society, 1850, but during my investigations had discovered an intermediate form, which agrees with the descriptions of *Alveolites capillaris* of Prof. Phillips in his Geology of "Yorkshire," 1836. Although the description given by Phillips is meagre, yet M. Edwards and J. Haime refer to it, and regard it as an intermediate variety between *Alv. septosa* and *Alv. depressa*. But I have to record another variety, which differs widely from those forms, and appears to be altogether new.

The difficulties that present themselves in the proper identification of this and allied groups have long deterred me from recording the results of my investigations, and to trace within the limits of the present communication the different opinions recorded by former authors is more than my time will permit. The results of these investigations have been so ably summarised by Milne-Edwards and J. Haime in their memoir, that it renders it undesirable. Indeed, did my limits admit, it would be difficult and perplexing, as it is more or less certain that several authors, while describing the structural details that guided them in their identification, have, however, described portions of the same coral under different names.* To prove that such does exist, we have only to examine the specimens in many of our museums. Yea, even genera that have recently been founded can be shown to have barely even specific value. This result has evidently arisen from varied causes. First, such may have arisen from determining both genera and species from the examination of external aspects, which doubtless is the cause of a great deal of confusion, as the external aspects of all species varies—a result brought about by the aptitude of the polype to adapt itself to external conditions; and another source of confusion arises from describing species from aberrant forms and single examples. It is well known that fossil corals cannot be satisfactorily determined unless there is an extensive series to select from. And no better example could be given than the varieties that are present in the group under consideration. If the specimen selected for description represents the superior portion of a mass, it will be apparent that the form of the calices has been regulated by their surroundings. In their normal form they are cylindrical and spherical; but in compound masses they are more or less affected by the lateral pressure of the neighbouring corallites and the mode of reproduction, and are usually found more or less prismatic in outline, and varying in proportion to their surrounding conditions.

If, however, the selected specimen is from the lateral margin of the mass, the corallites may be cylindrical and spherical at their free ends; or they may be laterally pressed on the one side, and consequently semicircular; or they may be crushed on three sides, and rendered more or less triangular; or there may be greater pressure on two of the sides, and consequently elongated laterally; and may thus be produced triangular, pentagonal, hexagonal, and heptagonal. Amidst the specimens that are lying before me all those conditions are present—indeed, in one variety nearly all the different forms present themselves.

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* M. Edwards and J. Haime's Monograph of British Fossil Corals, Palæontological Society, 1850, gives the following list of authors that have described forms which they believe could only be referred to the genus *Alveolites*:—

Favosites septosus—Fleming, Brit. Anim., page 529. 1828.
„ „ —S. Woodward, Syn. Tables of Brit. Organic Remains, page 5. 1830.
„ „ —Phillips, Geology of Yorkshire, 2 parts, page 200, Part II., figs. 6, 7, 8. 1836.
„ „ —M'Coy, Syn. of the Carb. Foss. of Ireland, page 192. 1844.
Chætetes septosus—Keyserling, Reise in Petschora-land, page 183. 1846.
„ „ —M'Coy, Brit. Palæoz. Fossils, page 82. 1851.
Alveolites septosa—M. Edwards and J. Haime, Pal. Foss. des Terr. Palæoz., page 259. 1851.

There is, however, another cause, which cannot be overlooked—viz., the constant and persistent tendency to modification, not only in this group, but also in all the groups of coralline remains from the carboniferous system. Indeed, the modifications are so slight in all that, unless there is a very extensive suite of specimens to examine, it is hazardous to express an opinion.

In the communication referred to above I stated that, from the examination of a large series of specimens, I was convinced that the teeth-like projections seen in many of the corallites, and referred to by M. Edwards and J. Haime as belonging to the septal system, were in no way related to the septa; and I gave a brief description of *Alveolites septosa*, *Alv. depressa* (E. and H.), *Alv. capillaris* (Phillips), and *Alv. Etheridgii* (Thomson), and observed that in well-preserved specimens of all the species these teeth-like processes are well exposed. And from the examination of both transverse and longitudinal sections, I felt the desirability of some other explanation than that these processes were related to the septa. That they do not belong to the septa was suggested from the fact that these processes can be traced from minute points to projections in every stage of development, passing through the calix, and becoming united to the opposite wall. This opinion is further corroborated by observing in longitudinal sections the cut-ends of the young corallites, which are seen springing from the wall, and resting upon the superior face of the tabula of the parent corallite; and that their growth and increase give rise to the curved and deflected aspect of the corallites so frequently seen in all the specimens that have come under my observation.

From the obscure nature of the details upon which several authors rested their definitions of both generic and specific distinction, I subsequently felt the desirability of not publishing that communication until I had procured additional evidence, and had had additional sections prepared—a course which I have the greatest pleasure in having adopted, as the results have been most satisfactory. This was further suggested by the discovery of a weathered specimen in the rotten limestone in Cunningham Bedland, near Dalry, Ayrshire. Upon this specimen we have not only exposed the mural pores, but, in several parts of the corallum, patches of the mass have been arrested in the upward growth by being covered by impure sedimentary matter. Here and there, however, there is exposed small groups of corallites that have not been so disturbed, and consequently they have outgrown the surrounding forms; and we have thus not only the mural pores exposed along the lateral faces of the corallites, but also, these patches not being affected by lateral pressure, their normal spherical form is preserved. From suggestions so important I felt the desirability of further delay. I therefore again visited all the localities throughout the country, and collected all the evidence procurable, and found in Charleston Lime Quarry, Fifeshire, examples of *Alveolites depressa*, Edwards and Haime (*Chætetes hyperboreus*, Nicholson and Etheridge)—several specimens that had been long exposed to the atmosphere, from which all the shale had been weathered off, thereby exposing the mural pores in the most perfect condition. Since then I have exposed to the weathering influence of the atmosphere, on the window sills of my house, a great number of specimens, and have by those means weathered a large series of sections, upon which the mural pores are abundantly exposed, and have made sections of a large series of specimens.* With evidence of such a satisfactory nature, I feel justified in placing the results of my investigations before the Society. Before I had accomplished my intentions, Professor H. Nicholson and Mr. Robt. Etheridge, Jun., in a communication to the Linnean Society, May 3rd, 1877, entitled "Notes on *Alveolites*, *Lamarck*, and on some allied Forms of Palæozoic Corals," state that the teeth-like bodies exposed in many of the calices have really no relation to the septal system. They also delete the two species of *Alveolites* described by M. Edwards and J. Haime from the list of the carboniferous fauna, and place them in the genus *Chætetes*. This decision they arrived at from the non-discovery of mural pores, and the absence of oblique calices in *Alv. septosus* and *Alv. depressus*, Fleming, an alteration which will by-and-by be seen to be groundless and premature; and I believe that their conclusions have been arrived at from imperfect data. In order that this may be better understood, I will give the original description of Lamarck, and also of M. Edwards and J. Haime, and briefly refer to the reasons assigned by these excellent observers for their determination.

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* In the preparation of a number of gigantic sections I have to acknowledge my indebtedness to Bailie James Blackwood, manufacturer, Kilmarnock, who most kindly fitted up cutting machinery in connection with the steam power of his mills, and cut and prepared for me a considerable series of the larger specimens, thereby enabling me to examine the transitions that present themselves in the larger specimens of the series. To him I offer my cordial thanks for his invaluable assistance.

The genus *Alveolites* was founded by Lamarck in the first edition of the "Système des Animaux sans Vertèbres" (published in 1801), p. 375, for the reception of a Devonian species, which he described under the name of *Alveolites suborbicularis.* The original definition is "Polypary stony, thick, globular, or hemispherical, formed of numerous concentric layers, which are superimposed one upon the other, each layer formed by the union of alveolar, subtabular, prismatic contiguous cellules [or tubes] forming a network on the surface." He subsequently, in 1816, in the "Hist. Nat. des Anim. sans Vertèb.," added encrusting forms. In the second edition of Lamarck's "Hist. Nat. des Anim. sans Vertèbres" (published in 1836), that portion relating to the corals was revised by Milne-Edwards, and the genus *Alveolites* was described as follows (Vol. ii., p. 285):—"Corallum stony, sometimes encrusting, sometimes free and massive, formed of numerous layers which are concentrically superimposed upon one another, each layer composed of tabular, alveolar, prismatic cellules, which are somewhat short, and form a network on the surface."

In the *Transactions* of the Palæontological Society, 1850, p. 60, Milne-Edwards and J. Haime place the genus *Alveolites* in the group of the *Favositidæ*, characterised by the presence of mural pores and the rudimentary condition of the septa.

In the "Historie Naturelle des Coralliaries" (Vol. iii., p. 26[illegible]), 1860, M. Edwards remarks—"The most striking character of the *Alveolites* is the septal system, which is represented by three teeth or vertical projections—one situated on the inside face of the outer lip of the calice, the others opposite the preceding, upon the inner lip of the corallites, and sometimes rudimentary. The calices are oblique, and pierced by a small number of pores; tabula complete and horizontal." . . . "The elongated teeth or vertical projections which we see in the interior of the visceral chambers of the corallites form the most peculiar character of *Alveolites*, and recall the three principal septa which characterise the genus *Heterocœnia* amongst the *Astræidæ.* It is also worthy of note, that one of the septa projections is more developed than the other two, and often it alone may exist."

At p. 356, Nicholson and Etheridge summarise the above, as follows:—"In briefly analyzing the above it will be obvious, in the first place, that Lamarck's definition of the genus *Alveolites* does not contain a single character which would at the present day be regarded as of generic importance at all; so that the ultimate existence of the genus will depend upon whether the type species—*Alv. suborbicularis*, Lamarck—can be shown to possess characters which separate it generically from allied forms. In the second place, the various definitions given by M. Edwards and J. Haime yield upon collation the following characters as essentially distinctive of the genus *Alveloites*, as understood by them:—(1) The corallites are furnished with lamellar walls, and are not united by any cœnenchyma. (2) The visceral chambers are traversed by well-developed horizontal tabulæ. (3) Mural pores, comparatively large and few in number, are present. (4) The corallites are oblique, shorter than *Favosites*, and terminated by oblique semilunar or subtriangular calices. (5) There exist in the interior of each corallite three elongated teeth, which represent the primary septa, and of which one is always larger than the others, and may be the only one present. (6) The corallites are arranged in the massive and encrusting forms in superimposed layers."

These authors discuss at great length the reasons why they believe that *Alv. septosus* and *Alv. depressus*, Fleming, must be referred to the genus *Chætetes*, Fisher. At page 366 they state:—We are disposed, then, to believe that mural pores are really existing in *Alv. septosus*, Fl., *Alv. depressus*, Fl., and *Chætetes*, Fisher; and we may add that M. Edwards and J. Haime expressly affirm the absence of pores in the latter. If this view be correct, clear that the two first-mentioned of these forms can no longer retained in *Alveolites*, from which they further differ in their comparatively erect corallites and their non-oblique calices." And page 367 they summarise the whole as follows:—"Upon reviewing all the above evidence, it seems to us to be clear that *depressus*, Fl., and *Alv. septosus*, Fl., can no longer be retained the genus *Alveolites*, as typified by *Alv. suborbicularis* and its [illegible]. On the other hand, if more extensive investigation confirm, we believe they will, the absence of mural pores, these species must be placed in the genus *Chætetes* side by side with *Chæ. radians*, Fisch., and they will stand as *Chaetetes depressus*, Fl., and *Chaetetes septosus*, Fl.

From the above, it will be apparent that these authors rest generic affinity upon three points — (1) The non-existence of mural pores; (2) the great length of corallites; (3) and the obliquity of the calices.

Regarding the first of these objections, I have many specimens in which mural pores are present. Before, however, I ventured to express an opinion, and being desirous that there should be no dubiety in the matter, I requested some of our ablest Palæontologists to examine a number of the specimens, not even hinting what they were to look for, and each, independently and separately, and unknown to each other, observed irregular mural pores. Having thus my own observations confirmed, I felt persuaded that that objection must fall to the ground. As regards the second point, the length of the corallites entirely depends upon what part of the corallum we examine. If near the central area, the corallites will be found to be of greater length than they are towards the lateral margin—a result produced by the fissiparous mode of reproduction. Their length also depends more or less upon the vitality of the polyp when in life. Specimens lie before me, in some parts of the mass of which the teeth-like processes are found in almost every corallite; in some there is one, in others there are two and three, whilst in the same mass there are numerous corallites in which these projections are totally awanting. As regards the third point, the obliquity of the calices rests also entirely upon what part of the corallum is examined. If towards the margin, or in the earlier stages of fissiparity, they may be seen not only oblique, but also triangular, sub-triangular, pentagonal, hexagonal, and in some instances heptagonal in outline. I have specimens from the carboniferous rocks in which all those conditions are seen, and also a specimen of *Alveolites suborbicularis* from the Devonian rocks, Eifel,* which exhibit the corallites without any oblique calices upon the summit of the mass, whilst towards the margins the corallites are oblique, compressed, triangular, and sub-triangular. Indeed, this specimen from the Eifel has such a close resemblance to some of the carboniferous varieties that, had I not been made aware that it was a Devonian specimen, I would have regarded it as belonging to the carboniferous forms.

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* For this specimen I am indebted to Mr. James C. Christie, to whom I offer my cordial thanks.

As regards the affinity of *Alveolites septosa* and *Alveolites depressa*, E. and H., to the genus *Chætetes*, I fail to find one character in common. In the latter I have been unable to detect mural pores. Edwards and Haime state that there are none. Further research may reveal such, but with our present knowledge, which is founded upon the examination of a large number of specimens, not only from the carboniferous rocks of Britain, but also from the examination of specimens from the Silurian rocks of Sweden, which were kindly sent to me by Dr. Lindstrom, I have been unable to detect the slightest trace of mural pores; consequently that objection must fall to the ground.

There is, however, another, and what seems to me to be a more fatal, objection. In *Alveolites* the mode of reproduction is by fissiparity, while in *Chætetes* the mode of increase is intermural, which can be traced in every stage of development—first, as a thickening of the wall in the angles of the adjoining corallites, then a minute pore is observable, which, in the very earliest stage, is often elliptical in outline, and shallow. On further growth tabulæ are observable, and as a result of their growing side by side with the parent corallite, they become more or less prismatic from lateral pressure. The genus thus multiplies outside the parent corallite, and resembles in this respect the Sclerobasic group. Indeed, *Chætetes* and *Stenopora* approximate so closely in the mode of gemmation to the *Bryozoa* that I am more or less inclined to place them as an intermediate group between the *Bryozoa* and the Tabulate corals.

The only species of Favosites yet discovered in the carboniferous system is *Favosites parasitica*, M'Coy. Here gemmation is intermural, and always takes place at the angle of the parent corallites. But while *Chætetes* and *Favosites* possess this character of development in common, they differ widely in the fact that mural pores have not yet been detected in the former, while in the latter they are always present, and arranged in the most systematic order, which has been regarded of sufficient value to warrant generic distinction.

These points may be briefly summarised as follows:—Favosites may be readily distinguished (1) by the presence and arrangement of the mural pores, (2) by the mode of development—the carboniferous being intermural, and, in some of the Silurian forms, calicular, and always at the angles of the parent corallites.

And *Chætetes* may at all times be recognised (1) by the flat encrusting sheets and dendriform masses, (2) the non-existence of mural pores, and (3) by the intermural development of the corallites.

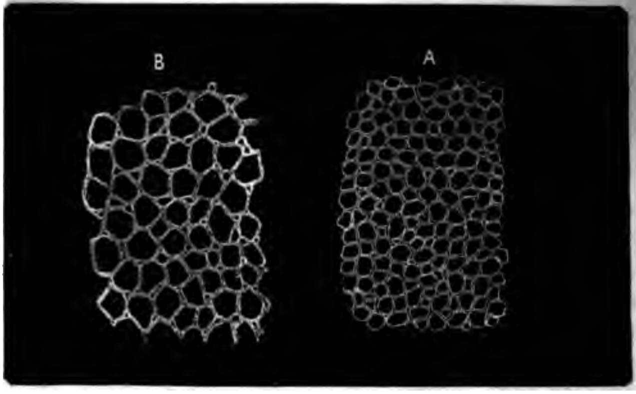
Alveolites is distinguished (1) by the form and arrangement of the calices, (2) by the fissiparous mode of development, (3) by the presence of mural pores, and (4) by the form and aspect of the corallum.

These genera present the following characters, described from the actual specimens:—

FAVOSITES.—Fig. 1A.

Corallum compound, composed of prismatic corallites, and arranged in superimposed layers. The calices are pentagonal and hexagonal. Tabulæ complete and numerous. The mural pores are abundant and arranged in rows; and the under surface is covered with a wrinkled epitheca, and terminating at a point. The development is intermural, and always arising at the angle of the parent corallites. The specimens are from the Silurian of Sweden, the Devonian of the Eifel, and from the Carboniferous of Scotland.

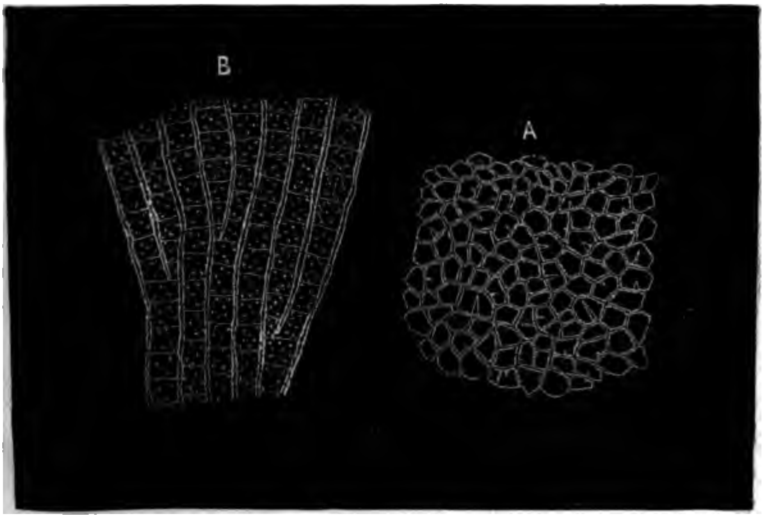
Fig. I.



CHÆTETES.—Fig. 1B.

Corallum compound, forming thin, flat, encrusting sheets, dendriform. Some forms are in small, dome-shaped masses; calices circular and prismatic; development intermural, and always at the angles of the parent corallites. The new cells, which are first seen to be a mere thickening of the intermural space, in the earliest stages are elliptical in outline, but in further development become an elongated depression, and gradually assume a circular outline. In a newly-formed calice the cavity is comparatively shallow; on further growth the tube of the calice becomes elongated, and secretes a transverse plate or tabula. The tabulæ are numerous and complete. The specimens are from the Silurians of Sweden, the Devonian of the Eifel, and the Carboniferous of Scotland.

Fig. II.



ALVEOLITES.

Corallum compound, composed of closely-aggregated spherical corallites, when free from lateral pressure; when affected by lateral pressure they are prismatic, and more or less arranged in superimposed layers.* Calices circular when free from lateral pressure; they are, however, usually oval, triangular, pentagonal, hexagonal, and heptagonal, in the large compound masses where they are more or less affected by lateral pressure. The walls are perforated by irregular mural pores. The increase is by fissiparity. In some instances it is found in irregular, flat sheets, and terminating at a point on the under surface. It seems to have been attached to foreign bodies and covered with a wrinkled epitheca, whilst other forms are periform, irregularly hemispherical, and mammalar-encrusting masses. Several of the species are frequently found encrusting the ventral valve of *Productus giganteus*. I have specimens as mere thin encrusting sheets, with a continuous series increasing in height up to fifteen inches.

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* The superimposed layers are usually accompanied with impure foreign matter, which has been floated and distributed over the mass, and which has disturbed the continuity of the upward growth of the corallites, as all over the parts where the impurities are the tabulæ are uniformly deposited, and more numerous than they are in any other part of the corallum, and thus gives rise to the layer-like aspect so frequently seen in this group.

As regards the affinity and classificatory position of *Alveolites*, the above account of the structure leaves little doubt that the carboniferous species is more nearly allied to the *Alveolites* of Lamarck than they are to any other group. They agree with Lamarck's description in possessing mural pores, and the fissiparous mode of gemmation, and there can be no reasonable grounds for erasing that genus from the carboniferous fauna, and placing them amongst the species of a genus that was established nearly thirty years after the creation of *Alveolites*. Indeed, I cannot accept the views of Nicholson and Etheridge, as recorded in the *Transactions* of Lin. Society, vol. xiii., p. 367, who place them amongst the *Chætetedæ*. They appear to me, on the contrary, to form a distinct special group, distinguished from *Chætetes* not only by the more massive aspect many of them assume, but also by the possession of mural pores, the mode of development, the total absence of the small intermural zooids, by their invariable deflected mode of growth, and by the fact that *Chætetes* is usually found in flat, encrusting sheets of no great height. In *Chætetes*, on the other hand, the mode of development is well seen; the young corallites are developed within elongated depressions, hollowed out of the calcareous wall of the parent, and protected by the wall which projects on the surface of the contiguous walls, showing themselves, when examined by a magnifying glass, as small elongated warts, with a depression in the centre. Indeed, with the mass of illustrations before me (amounting to several hundredweights) as to the structure of *Alveolites* of Lamarck, it is impossible to establish any satisfactory generic relation between this group and *Chætetes*; and this view was the one finally adopted by Edwards and Haime. Was there no other evidence, the possession of perforated walls and priority separates them from the family of the *Chætetedæ*. Indeed, the more I investigate the corals of the carboniferous system, the more am I persuaded of the constant tendency of variation which all species show, and that the varied forms of coralline remains have been gradually evolved in a slow gradation of increasing complexity, produced by the adaptation of structure and function to external conditions. Meanwhile, we can only select central types, from which both genera and species diverge in both directions. And I trust that the descriptions given of the genus *Alveolites* is sufficiently distinct to warrant me in retaining the genus as occurring in the carboniferous series. The details coincide closely with the definition of Lamarck, and that of M. Edwards and J. Haime, unless in the angularity of the calices. Before, however, we seek to speculate upon the angularity or the non-angularity, we ought to keep in mind that either of these conditions essentially depend upon what part of the corallum Lamarck examined (as referred to at page 10). If from the summit, then the corallites are seen not to be angular, but they possess the teeth-like processes, or fissiparous division, in a less degree; while a section taken from the lateral margin not only shows the calices to possess the angularity, but there is also a great increase of the fissiparous projections in the interior of the corallites.

Alveolites septosa. Edwards and Haime.

Plate I.—Figs. 1, 1A.

Specific Characters.—Corallum in broad encrusting sheets, spherical and pyriform masses, and more or less mammalated, and frequently found encrusting the ventral valve of *Productus giganteus.* The corallites are pentagonal and hexagonal, and are a third of a line in diameter, and from five to eleven lines long. The tabulæ are well developed, and there are from four to six in a line. In some forms along their interior there are rows of minute elongated granules (Plate I., Figs. 2, 2A), whilst in other forms they are almost destitute of the granular structure. There are mural pores, and of large size, which alternate between the granular rows (Plate I., Fig. 7). They increase by fissiparity, and the teeth-like projections may be seen in well-preserved specimens as minute points, and can be traced extending across the calice, and becoming attached to the opposite wall (Plate I., Figs. 3 and 8).

Formation, Carboniferous; Locality.—Found in beds of impure limestone at Oatecraigs, Dunbar, Haddingtonshire; Petershill, Bathgate; Weston and Boghead, Lesmahagow, Lanarkshire; Garsewater and Asheyburn, near Muirkirk, Ayrshire. In the latter locality, I have found specimens encrusting the ventral valve of *Productus giganteus* in thin sheets of half an inch up to masses fifteen inches in height, while in some forms found at Dunbar (where Dr. Fleming got his type *Favosites depressus* from), they are in dome-shaped encrusting sheets. One of these I measured. It was twenty-two inches in diameter. This variety approaches so closely to the genus *Favosites* that there need be no surprise at Dr. Fleming placing it in that group. Indeed, unless there is both transverse and longitudinal sections examined it would readily be placed as belonging to that genus. The corallites are longer than is found in any other species of *Alveolites*, consequently there is a proportionate absence of fissiparous division; and if, in the absence of a longitudinal section, a transverse section is only examined, and more especially an unpolished section, it would be placed by many palæontologists as belonging to *Favosites*. The type specimen of Dr. Fleming* is rough and granular, and resembles *Favosites*, but, when sectioned, we find the fissiparous mode of development throughout the mass—a characteristic which is always present in *Alveolites*, and quite distinct from the structure of *Favosites*, and therefore must be placed in the genus *Alveolites*, and forms an interesting connecting link between *Favosites* and the more pronounced forms of *Alveolites* of Edwards and Haime. One of the specimens from Asheyburn is so coarsely granular that I did regard it as a variety of *Pachypora Lindstrum*, but when carefully-sectioned specimens are examined, the Alveolitic type is clearly pronounced. In another specimen from the same locality there are occasionally seen minute intermural pores or young corallites, which is the characteristic of the genus *Chætetes*. The structural details of *Alveolites*, however, largely predominate, and therefore we can only regard such forms as mere varieties between *Favosites* and *Alveolites* on the one hand, and on the other as between *Alveolites* and *Chætetes*—a relation which, when our knowledge of the fossil corals of the carboniferous system is more accurate, will be found to exist, not only in this group, but also in all the other genera found in that system.

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* Through the kindness of Dr. Traquair I was permitted to examine the type specimen, which is in the case containing Dr. Fleming's collection in the Industrial Museum, Edinburgh.

Alveolites depressa. Edwards and Haime.

Plate I., Figs. 4, 4A.

Specific Characters.—Corallum hemispherical, pyriform, or in thin, flat, undulating sheets. Corallites pentagonal, rarely hexagonal, and from a tenth to the fourteenth of a line in diameter, and from three to five lines in length. The fissiparous development of the young corallites are seen in some forms as minute points, and in others in every stage, till they reach the opposite wall of the corallite. The mural pores are large, and surrounded with a raised lip.

Formation, Carboniferous; Locality.—Found in thin encrusting sheets at Charleston, Fifeshire;* Braidwood, Lanarkshire; Garsewater and Asheyburn, Muirkirk, Ayrshire. In the Braidwood and Muirkirk districts this species is found in more or less dome-shaped masses, whilst at Charleston it is in thin, flat sheets, from two lines to three-quarters of an inch in thickness, and the under surface is covered with an irregular wrinkled epitheca, and attached to foreign bodies.

I was inclined to regard the variety of this species that is found at Charleston as belonging to the genus Chætetes, but finding the mural pores and the fissiparous development, I felt satisfied that it could not be placed amongst that genus.

Alveolites capillaris. Phillips.

Part I., Figs. 5, 5A.

Specific Characters.—Corallum in large hemispherical masses and thin encrusting sheets. I have one mass seven inches in diameter and nine inches in height. Corallites from three to seven lines long. In no instance have I seen more than one of the teeth-like processes in a calice. This fissiparous mode of development is present in all stages, from mere points, and extending across and attached to the opposite side of the corallite. The walls are thin and smooth. The corallites are from a sixth to a tenth of a line in diameter. The tabulæ are well developed, and about a seventh of a line apart. The mural pores are large.

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* This is *Chætetes hyperboreus* of Nicholson and Etheridge.

I was long disposed to regard this species as a variety of *Alv. depressa*, E. and H. It is, however, distinguished by its thin, smooth walls, larger corallites, and is found in much larger masses. Milne-Edwards and J. Haime considered it to be an intermediate form between *Alv. septosus* and *Alv. depressus*, Flem. From the examination of a large series of specimens, this opinion I cordially endorse.

Formation, Carboniferous; Locality.—Found in the lower limestone series, in large hemispherical masses, at Crossford and Boghead, Lanarkshire; Asheyburn and Garsewater, near Muirkirk, Ayrshire; and in thin encrusting sheets at Petershill, near Bathgate.

Alveolites Etheridgeii. Thomson. Sp. nov.

Plate I., Fig. 6, 6A, 6B, 6C, 6D.

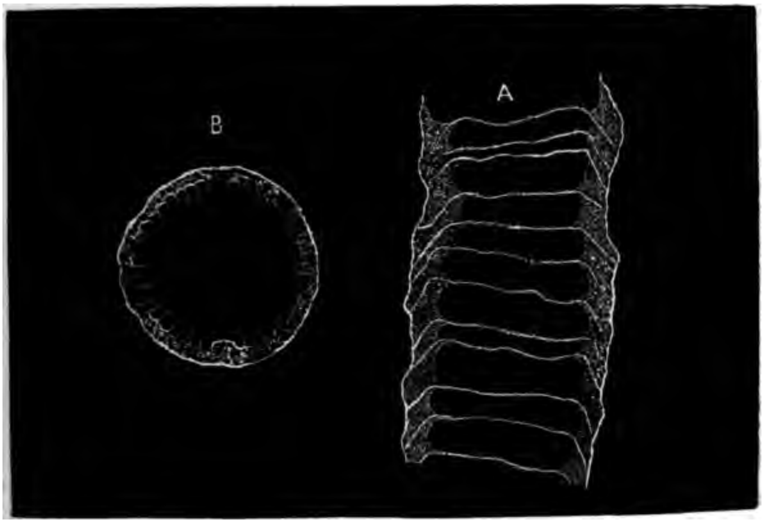
Specific Characters.—Corallum in irregular pyriform and hemispherical masses, and more or less mammalated. It is frequently found in tri-mammal masses. Corallites irregular and large; some are pentagonal, hexagonal, heptagonal, and sub-rhomboidal, and from six to ten lines long. The walls are thin and granular. The tabulæ are close, and about a seventh of a line apart. The calices are large, and granular in the interior. Some are one line, whilst others are a third of a line in diameter. They are here and there arranged throughout the mass in sub-stellate groups, radiating irregularly around a large central corallite (Plate I., Figs. 6, 6D). Some of these are fully two lines long and a third of a line broad. In the neighbourhood of these radiate groups the surface is more or less vermicular in external aspect. In the latter the fissiparous development is frequently present; and in all fissiparity may be traced, in every stage of development, from minute points to the attachment of the plate to the opposite wall. There are large mural pores. This species is frequently found in large masses—I have a portion of a mass, the original was fully a hundredweight. It is also frequently found as a parasite upon the ventral valve of Productus giganteus.

Formation, Lower Carboniferous; Locality.—Found at Catecraigs, Dunbar, Haddingtonshire; Blackridge, near Ecclefechan, Dumfriesshire; Asheyburn and Garsewater, near Muirkirk, Ayrshire.

I have great pleasure in naming it after Mr. Robert Etheridge, Jun., F.G.S. He was kind enough to show me the first specimen that had come under my observation, in July, 1876. Since then I have discovered it in the other localites enumerated.

Genus *Amplexus*. Sowerby.

Fig. III.



Generic Characters.—Corallum simple, sub-cylindrical, cylindrical, and tapering towards the base; frequently tall, and more or less twisted. The epitheca is thin, with encircling lines of growth and accretion ridges. The septa are delicate and short—they never reach to near the centre of the calice (Fig. 3B). The tabulæ are well developed, extending completely across the visceral chamber, and invariably exposed over a wide central area into which the septa do not penetrate (Fig. 3A). A septal fossula is present, which is usually formed by a slight lateral depression of the tabulæ. The calice is usually circular and shallow, with a thin margin.

The genus Amplexus was established by Mr. Sowerby* for the reception of a group of corals which form a natural and intermediate series between the compound tabulate forms, as *Alveolites*, and that of the genus *Zaphrentis*. Typical examples of the former, however, are readily and completely separated from *Alveolites* in the possession of rudimentary septa, whereas, in the latter the septa are awanting; and from *Zaphrentis* by the septa being less developed, and the more rudimentary septal fossula. Owing to the rudimentary condition of the septa, there is invariably a space in the centre of the corallum which is occupied exclusively by the tabulæ. The septa afford one of the most striking characters of the genus, being invariably short and comparatively rudimentary. This is well seen in *Amplexus coralloides*, Sow., Plate II., Figs. 1, 1A, 1B. They differ in length, but in most of the species of the genus they never extend inwards towards the centre of the visceral chamber more than about a third of the total diameter, whilst in most species they are shorter than this. There is no secondary septa developed, and there may or may not be interseptal dissepiments present; whilst these, when present, are always comparatively simple and few in number.

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* Sowerby's "Mineral Conchology," vol. i., p. 165.

The tabulæ are well developed, and are, with one exception, bent in a more or less marked manner downwards at their outer extremities.

The calice is circular and shallow, with a thin upper margin. Owing to the shortness of the septa, the bottom of the calice is nearly flat, and formed by the superior surface of the upper tabula.

The carboniferous forms, so far as I have observed, are restricted to the lower members of the system.*

Amplexus coralloides. Sowerby.

Plate II., Figs. 1, 1A, 1B.

Specific characters.—Corallum simple, cylindrical, tortuous, and tapering towards the lower extremity. The epitheca is thick, with encircling lines, and broad, shallow annulations of growth.

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* For the identification of a number of the species of this and the genus Zaphrentis, I cordially offer my thanks to Prof. L. de Koninck, Liège, M. Dupont, Brussels, and my gratitude to the memory of the late Dr. Nyst, Brussels, who rendered me invaluable aid by allowing me the use of Prof. Koninck's type specimens out of the National Collection, Brussels, for comparison, by which means I am enabled to name many of the Scottish species from the most reliable data.

The calice is circular and moderately deep. The septa are of one order, marginal, and extend inwards for about one and a-half line, and are wide apart. There are forty-six septa in a corallum one inch in diameter, and between each septum there is one interseptal dissepiment. A septal fossula is present, and formed by a slight depression of the tabulæ, and one septum, half the length of the others, extend into it.

Height of corallum (incomplete), 5 inches; diameter of calice, 1 inch.

Formation, Carboniferous; Locality.—Found in impure limestone that overlies the productus limestone, near the base of the marine series of the carboniferous system, at Broadstone, Beith, Ayrshire, and Brockley, Lesmahagow, Lanarkshire.

This species, so far as our present knowledge goes, is rarely found in Scotland, and, when found, it is usually imbedded in impure limestone.

Amplexus Sowerbii. Phillips.

Plate II., Figs. 2, 2A.

Specific Characters.—Corallum simple, short, cylindrical and conical at the base. The epitheca is thin, and marked with shallow, irregular annulations and encircling lines of growth, and there are faint longitudinal ribs. The calice is circular and shallow; the septa minute and hardly discernible. There are twenty-two septa, and there is no interseptal dissepiments. The fossula is small, and one of the septa, of shorter length than the others, extends into it. The tabulæ are sparse, and extend across the visceral chamber from wall to wall, and are fully a line apart.

Height of corallum, 1 inch; diameter, 3 lines.

Formation, Lower Carboniferous; Locality.—Found in a bed of shale that is interstratified with the upper thin beds of limestone, near the base of the marine series of the carboniferous system, at Brockley, Lesmahagow, Lanarkshire.

This interesting species may be said to be the intermediate form between the genus *Alveolites* and that of *Amplexus*. It, however, being single, and there being no mural pores, it must be placed with the latter genus, and will therefore form the connecting link between those two genera.

Amplexus serpuloides. De Koninck.

Plate II., Figs. 3, 3A, 3B.

Specific Characters. — Corallum simple, cylindro-conical, and twisted. The epitheca is thin, and marked with shallow annulations and crenulate, encircling lines of growth and delicate longitudinal ribs. The calice is circular and shallow. There are twenty septa, which are short and delicate, and there are faint indications of interseptal dissepiments. The fossula is shallow, and indicated by a slight depression of the tabulæ, and a septum a little shorter than the others extends into it. In the longitudinal section the tabulæ are irregular, and extend across the whole width of the visceral chamber, and close to the wall they are slightly bent downwards.

Height of corallum, 1 inch ; diameter at the broadest, 3½ lines.

Formation, Carboniferous ; Locality.—Found in a bed of shale that is interstratified with the thin bands of limestone, near the base of the carboniferous system, at Brockley, Lesmahagow, Lanarkshire.

Amplexus nodulosus. Phillips.

Plate II., Figs. 4, 4A, 4B, 4C.

Specific Characters.—Corallum cylindro-conical, flexuous, and acute at its base. The epitheca is stout, and marked with acute narrow annulations and crenulate, encircling lines of growth, and irregular nodular prolongations, which are more numerous near the inferior extremity. The calice is circular and shallow. The septa extend inwards for fully a line. There are twenty-three in a corallum, five lines in diameter, and each is united by interseptal dissepiments, which are few in number.

The fossula is small, and one septum, of shorter length than the others, extends into it. The longitudinal section exposes the broad tabulæ, which are two-thirds of a line apart, and which bend downwards at their lateral margin.

Height of corallum, 1 inch 5 lines ; diameter of calice, 5 lines.

Formation, Carboniferous ; Locality.—Found in shale that is interstratified with the thin bands of limestone, near the base of the carboniferous system, at Brockley, Lesmahagow, Lanarkshire.

Amplexus spinosus. De Koninck.

Plate II., Figs. 5, 5a, 5b, 5c.

Specific Characters. —Corallum simple, conical, and curved. The epitheca is thin and marked with crenulate, encircling lines, and irregular, shallow annulations of growth, and there are dispersed over its surface a few spinous processes, which point downwards. The calice is circular and shallow. The septa are lamellar for a third of their length from the periphery; they then are single, and taper to a point, and extend inwards for fully a line. There are twenty-six primary septa, and the secondary septa are represented by pointed granules, and each is united by remote and sparse interseptal dissepiments. In a longitudinal section the tabulæ are exposed, and are more or less flat in the central area, and at their lateral margins they bend downwards. The fossula is small, and a septum, half the length of the others, extends into it.

Height of corallum, 10 lines; diameter of calice, 6 lines.

Formation, Carboniferous; Locality.—Found in bands of shale that are interstratified with the thin beds of limestone, near the base of the carboniferous system at Brockley, Lesmahagow, Lanarkshire, and Roughwood, Beith, Ayrshire.

Amplexus irregularis. Thomson. Sp. nov.

Plate II., Figs. 6, 6a.

Specific Characters.—Corallum simple, cylindrical, and conical [illegible]ar the base. The epitheca is thin, and marked with longitudinal [illegible], shallow annulations, and crenulate, encircling lines of growth. [illegible]lice circular and shallow. The septa are irregular in length, [illegible]d lamellar. There are twenty-two, two long and two of them of [illegible]orter length alternately, and in the spaces usually occupied with [illegible] secondary septa there are very minute granules exposed on [illegible] inner face of the theca, and the interseptal spaces are occupied [illegible]th irregular and sparse interseptal dissepiments. The fossula [illegible] indistinct; between two of the short septa there is one of [illegible]orter length, which I take to be the fossula.

Height of corallum, 1 inch, 4 lines; diameter of calice, fully 3 lines.

Formation, Carboniferous; Locality.—Found in beds of shale that are interstratified with thin beds of limestone, near the base of the carboniferous system, at Roughwood, Beith, Ayrshire.

It is noteworthy, that in this and the preceding species we have presented the bilamellar septa, accompanied with an increased number of interseptal dissepiments, and somewhat irregular and slightly convex tabulæ, suggesting that it is only with the increased complexity of the internal structural details that the bilamellar septa begins.

Amplexus cornuformis. Ludwig.

Plate II., Figs. 7, 7A, 7B, 7C.

Specific Characters.—Corallum simple, cylindrical, and curved. The epitheca is thick, and marked with delicate crenulate encircling lines and shallow annulations of growth. The calice is circular and shallow. The septa are lamellar, and there are twenty-four in a corallum seven lines in diameter; and between each septum there is a large granule, occupying the space of the secondary septa, and may be regarded as the prototype of the secondary septa. The interseptal dissepiments are few in number. The longitudinal section is more or less bi-aerial (Plate II., Fig. 7B). In the central area there are irregular tabulæ, which are deflected downwards to the concave or ventral side of the corallum; and the interlocular area is occupied with irregular convex interseptal dissepiments, convexity pointing upwards and slightly outwards. In the longitudinal section, and where the interlamellar structure of the septa is exposed, the interlamellar spaces are seen to be occupied with a system of delicate vertical plates, which extend inwards and acutely downwards. There are six in the space of a line. These plates I regard as an expression of the retractile muscles of the polyp, and which I recorded as occurring in the interlamellar space in the *Transactions* of this Society last year—a discovery I made while investigating another point of great interest, and which I hope by-and-by to record. The fossula is large, and one septum, of shorter length than the others, extends into it.

Height of corallum, 1 inch 4 lines; diameter of calice, 7 lines.

Formation, Carboniferous; Locality.—Found in shale interstratified with the thin beds of limestone near the base of the carboniferous system, at Brockley, Lesmahagow, Lanark, and Charleston, Fifeshire.

Amplexus Haimeanus. De Koninck.

Plate II., Figs. 8, 8A, and 9, 9A.

Specific Characters.—Corallum simple, short, and turbinate. The epitheca is stout, and marked with shallow, irregular annulations and encircling lines of growth, and there are a few nodes irregularly dispersed over its surface. The calice is slightly oval and shallow. The septa are well developed and lamellar, and extend inwards to near the centre of the visceral chamber, and are united by numerous interseptal dissepiments. The central area is not quite a third of the total diameter of the corallum, and enclosed with transverse tabulæ. The fossula is small, and one of the septa, half the length of the others, extends into it.

Height of corallum, 6 lines; diameter of calice, 3 lines at the broadest and 2½ lines at the narrowest.

Formation, Carboniferous; Locality.—Found in bands of shale interstratified with the thin beds of limestone near the base of the carboniferous system, at Brockley, Lesmahagow, Lanarkshire.

Amplexus Henslowi. Edwards and Haime.

Plate II., Figs. 10, 10A, 10B.

Specific Characters.—Corallum simple, cylindro-conical, and slightly curved. The epitheca is very stout, and marked with irregular broad and shallow annulations and encircling lines of growth. The calice is circular and moderately deep. The septa are lamellar; and in the longitudinal section there are eight interlamellar vertical striæ in the space of a line. There are twenty-eight septa, which are variable in length, and are united by sparse interseptal dissepiments. The central area is occupied by irregular tabulæ, some of which extend to the wall on the ventral side of the corallum, whilst others stop short; and the interseptal space is occupied with large convex interseptal dissepiments, convexity upwards and outwards. The fossula is large, and a septum, of shorter length than the others, extends into it.

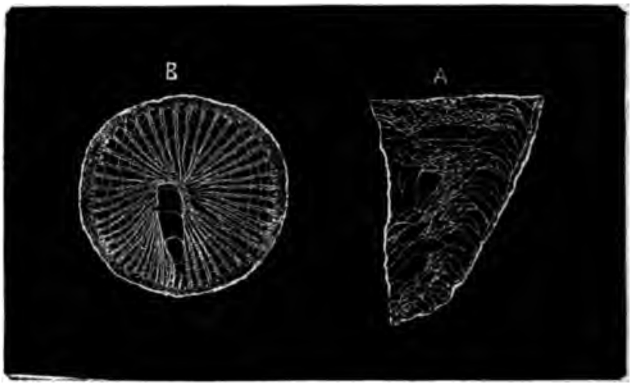
Height of corallum, 1 inch 3 lines; diameter of calice, 7 lines.

Formation, Carboniferous; Locality.—Found in a band of shale that overlies the lowest bed of limestone, at Broadstone, Beith, Ayrshire.

Genus *Zaphrentis.* Rafinesque and Clifford.

Aim. des Sci. Phys. de Brusseles, vol. v., p. 234.

Fig. IV.



Generic Characters.—Corallum simple, turbinate, conical, and cylindro-conical, and more or less curved. The calice is deep, with a large and conspicuous fossula, and formed by the coalescence of a portion of the septa, which at their inner ends fold round and form its walls (Fig. 4B.) The septa are all lamellar, and are well developed, extending in some forms to the centre, while in others a portion of them stop short. They then coalesce and become united, and converge to the centre of the visceral chamber; whilst in the simple or passage forms of *Zaphrentis*, and the more highly-developed form of *Amplexus*, the septa do not reach the centre of the visceral chamber.

There is no columella, the tabulæ are conspicuous and variable, and the septa are more or less prolonged over their superior surface.

The interseptal loculæ are filled up towards the outer margins of the corallum by remote convex dissepiments, and the tabulæ fall short of the circumference of the corallum, and rest upon the interseptal dissepiments, and generally have a downward curvature near the circumference; and this is usually more apparent on the ventral side of the corallum.

The general form of *Zaphrentis* is variable. Some are turbinate, and attain a moderately large size, whilst others are very small. The epitheca is variable; in some species it is stout, whilst in others it is thin, and is usually marked with accretion ridges, and fine encircling lines of growth. The calice is deep, and its upper margin is thin, and there is always a deep fossula. The most characteristic feature of the fossula, however, is the fact that it is formed by the coalescence of a greater or less number of the septa, which unite at their inner ends, fold round, and form the walls of the fossula.

Upon the whole, the genus *Zaphrentis*, as illustrated by the specimens found in Scotland, may be readily recognised by the complete, or comparatively complete, development of the septal system. The irregular development of the tabulæ, as presented in the longitudinal section (Fig. 4A), and the existence of a large and conspicuous fossula, which is formed by the coalescence centrally of a portion of the septa, which fold round and form its walls, and may be therefore regarded as an intermediate group between *Amplexus* on the one hand and *Densyphyllum Dybowskei* on the other. It is separated from Amplexus by the greater development of the septal system. In the latter there are no secondary septa in the more pronounced types, and the primary septa extend for a limited extent into the visceral chamber, and are usually of greatly shorter length; and the rudimentary development of the interseptal dissepiments in the more complete forms, and the greater development of the tabulæ, which usually extend from side to side across the entire space occupied by the visceral chamber; and from *Densyphyllum*, from the fact that in the latter the septa always converge, and unite in the centre of the visceral chamber, and the interseptal dissepiments are numerously represented; and from *Zaphrentis (Cyathophyllum) cylindricum*, with which it was long associated, by the fact that in *Zaphrentis* proper there is never developed the broad flat tabulæ and the dense zone of interseptal dissepiments that is always so abundantly developed in this and the allied species of Cyathophyllum. The genus is more abundantly represented in the carboniferous deposits of Scotland than in any of the former periods, and attains its greatest development in the lower members of that system. In the upper portion of the same series they are not only dwarfed and stunted in growth, but numerically less, and appear to be approaching extinction.

Zaphrentis Enniskilleni. Edwards and Haime.

Plate III., Figs. 1, 1A, 1B, 1C, 1D, 1E.

Specific Characters.—Corallum simple, tall, cylindro-conical, curved, and tapering to a point. The calice is circular, large, and deep, and thin at the lip of the periphery. The epitheca is moderately stout, and marked with longitudinal ribs and shallow annulations of growth. The septa are lamellar and stout, and on the dorsal side of the corallum they converge and coalesce at a third of its total diameter from the wall; and on the ventral side they converge inwards, and fold round and form the walls of the septal fossula. In a transverse section one inch in diameter there are fifty primary septa, and these alternate with an equal number of secondary septa, which are obscure, and represented by denticulate projections about half of a line in length. The interseptal area is occupied by rectangular dissepiments, which are few in number. The fossula is large and deep, and extends into the centre of the visceral chamber.

Height of corallum, $3\frac{1}{2}$ inches; diameter of calice, nearly 2 inches.

Formation, Carboniferous; Locality.—Found in the thin beds of shale which are interstratified with the thin beds of limestone near the base of the marine series, at Roughwood, Beith, Auchenskeoch, Dalry, Ayrshire; and at Brockley, Lesmahagow, Lanarkshire.

Zaphrentis Griffithi. Edwards and Haime.

Plate III., Figs. 2, 2A.

Specific Characters.—Corallum turbinate and curved. The epitheca is thin, and marked with shallow, irregular annulations and encircling lines of growth and longitudinal ribs. The calice is circular and deep, fully a third of the total length of the corallum in depth. The septa are lamellar, and converge to the centre of the visceral chamber, and are united to the inner end of the fossula. In a transverse section eleven lines in diameter there are thirty-eight primary septa, and the secondary are hardly recognisable, and represented by obscure tubercules, and each is united by curved interseptal dissepiments. The fossula is large and deep, and extends into the centre of the visceral chamber, and on the ventral side of the corallum a portion of the septa fold round and form its walls.

Height of corallum, 1 inch 9 lines; diameter of calice, 1 inch 1 line.

Formation, Carboniferous; Locality.—Found in the shale that overlies the main limestone, at Netherfield, Avon, Strathaven, Brockley, Lesmahagow, Lanarkshire; and Charleston, Fifeshire.

This species is readily distinguished from all the other species by its broad calice, deep fossula, and the septa are wider apart, and the open cellular tissue in the centre of the visceral chamber.

Zaphrentis patula. Michelin.

Plate III., Figs. 3, 3A, 3B, 3C, 3D.

Specific Characters.—Corallum simple, tall, conical, and curved, and tapering to a point. The epitheca is stout, and marked with longitudinal ribs, and broad, shallow annulations of growth. The calice is large and deep, and thin at the lip of the periphery. The septa are lamellar, thin, and of irregular length; some of them converge to the centre of the visceral chamber. In a transverse section of a corallum one inch in diameter there are fifty primary septa, which alternate with an equal number of secondary septa. The latter extend inwards from the periphery about half a line in length, and each is united by sparse rectangular interseptal dissepiments. The fossula is large, and situated in the ventral side of the corallum, and never reaches the centre of the visceral chamber, and a portion of the septa fold round and form its walls.

Height of corallum, 3 inches; diameter of calice, 1 inch 5 lines.

Formation, Carboniferous; Locality.—Found in beds of shale, which are interstratified with the thin beds of limestone near the base of the marine series, at Roughwood, Beith, Ayrshire.

Zaphrentis Bowerbanki. Edwards and Haime.

Plate III., Figs. 4, 4A, 4B, 4C, 4D.

Specific Characters.—Corallum simple, cylindro-conical, and slightly curved. The epitheca is stout, and marked with encircling stria, and broad, shallow annulations of growth. The calice is circular and shallow, and slightly everted. The septa are well developed, and extend more or less into the centre of the visceral chamber, and are slightly curved at their inner ends. In a transverse section thirteen lines in breadth there are forty-four primary septa, and the secondary are represented by minute and indistinct tubercules, and the interseptal spaces are occupied with rectangular dissepiments. In a longitudinal section the tabulæ are irregular and bend down towards the ventral side of the corallum, and there are irregularly-dispersed groups of convex cells attached at intervals to the tabulæ. There are exposed five interlamellar striæ in the space of a line on the dorsal side and near the lower extremity of the corallum. The fossula is large, and extends to the centre of the visceral chamber, and one septum, of shorter length than the others, extends into it.

Height of corallum, 2 inches 10 lines; diameter of calice, 1 inch 3 lines.

Formation, Carboniferous; Locality.—Found associated with Lithostrocian purceum in the shale that is interstratified with the thin bands of limestone that overlies the productus gigantea limestone, at Brockley, Lesmahagow, and at Shiels, East Kilbride, Lanarkshire, and Auchenskeoch, Dalry, Ayrshire.

Zaphrentis Guerangeri. Edwards and Haime.

Plate III. Figs. 5, 5A.

Specific Characters.—Corallum simple, tall, cylindro-conical, and curved. The epitheca is stout, and marked with encircling lines, and broad, shallow annulations of growth and delicate longitudinal ribs. The calice is circular and deep, and is fully a third of the total length of the corallum in depth. The septa are lamellar and stout near the periphery, and become thin at their inner ends, and do not reach the centre of the visceral chamber on the dorsal side of the corallum. In a section one inch and four lines in diameter there are forty-eight primary septa, and the secondary septa are hardly recognisable; they are represented by minute tubercules, and each are united by rectangular interseptal dissepiments. In a longitudinal section the tabulæ are irregular, and bend slightly down towards the ventral side of the corallum. There are six interlamellar striæ in the space of a line. The fossula is large, and extends into the centre of the visceral chamber on the ventral side, and two of the primary septa form its lateral walls. These are united at their inner ends, and fold round and form the wall in the centre of the central area.

Height of corallum, 3 inches 2 lines (it is, however, imperfect—a portion of the lower extremity is wanting); diameter of calice, 1 inch 8 lines.

Formation, Carboniferous; Locality.—Found in the bed of shale that overlies the bed in which Streptorhynchus crenestrea is so abundant, at Auchenskeoch, Dalry, Ayrshire.

Zaphrentis Edwardsiana. De Koninck.

Plate IV., Figs. 1, 1A.

Specific Characters.—Corallum simple, turbinate, and curved. The epitheca is marked with encircling stria, and broad, shallow annulations of growth. The calice is circular and shallow. The septa are lamellar, and short on the dorsal side. They extend inwards from the periphery for two lines, then they are attached to the broad, flat tabulæ, which extends across the centre of the visceral chamber for six-tenths of the total diameter of the corallum; while on the ventral side the septa extends into the centre, and a few of them coalesce and inpinge upon the dorsal half of the corallum. The secondary septa are short, and not more than a third of a line in length, and each is united by sparse and angular interseptal dissepiments. The fossula is large, and extends into the centre of the visceral chamber, and one of the primary septa, one line long, extends into it.

Height of corallum, 2 inches; diameter of calice, 1 inch 1 line.

Formation, Carboniferous; Locality.—Found in a bed of shale that overlies the bed of limestone that is about one hundred and twenty feet above the lowest bed of marine limestone, at Brockley, Lesmahagow, Lanarkshire.

This species is distinguished from all the other species of the genus by its broad central area, and the septa on the dorsal side of the corallum are considerably shorter; and from Zaphrentis Gurangeri, its nearest ally, by the thinner epitheca, and the septa do not extend so far into the centre of the visceral chamber.

Zaphrentis Cliffordana. Edwards and Haime.

Plate IV., Figs. 2, 2A.

Specific Characters.—Corallum simple, conical, and slightly curved. The epitheca is moderately stout, and marked with encircling lines and irregular annulations of growth and longitudinal ribs. The calice is circular and everted. The septa are lamellar, and stop short of the centre of the visceral chamber on the dorsal side of the corallum, and there are a series of irregular cells around their inner ends, which are attached to the wall of the large cell in the centre of the central area. In a section eight and a half lines in diameter, there are thirty-two primary septa. The secondary septa are hardly recognisable, and their place is occupied by inconspicuous granules, and the primary septa are united by curved interseptal dissepiments. The fossula is small, and situated on the ventral side of the corallum, and one of the primary septa, a third of the length of the others, extends into it.

Height of corallum, 1 inch 2 lines; diameter of calice, 9½ lines.

Formation, Carboniferous; Locality.—Found in the shale that overlies the bed of limestone in Boghead Quarry, near Hamilton, Lanarkshire.

Zaphrentis Phillipsi. Edwards and Haime.

Plate IV., Figs. 3, 3A.

Specific Characters.—Corallum simple, conical, and curved. The epitheca is stout, and marked with encircling lines and irregular shallow annulations of growth. The calice is circular and deep; it is not unfrequently a third of the total length of the corallum in depth. The septa are well developed, and do not extend to the centre of the visceral chamber on the dorsal side of the corallum, while on the ventral side they extend inwards to the central area, and a few of them fold round and form the walls of the fossula. In a section of a corallum five lines in diameter there are twenty-eight primary septa, which are stout, and lamellar near their outer margins, while towards their inner ends they are thin and pointed, and these alternate with an equal number of secondary septa, which extend inwards for half a line, and each is united by interseptal dissepiments, which are more or less curved. The fossula is large, and extends to the centre of the visceral chamber, and three of the septa, of shorter length than the others, extend into it. The central one is considerably the shortest, and not more than half a line in length. In the longitudinal section the tabulæ bend acutely downwards to the ventral side of the corallum, and there are eight interlamellar striæ in the space of a line.

Height of corallum, 11 lines; diameter of calice, 7 lines.

Formation, Carboniferous; Locality.—Found in a bed of shale, the bed in which *Streptorhynchus crenestrea* is found so abundantly, in Auchenskeoch, Dalry, Ayrshire.

Zaphrentis curvulena. Thomson. Sp. nov.

Plate IV., Fig. 4.

Specific Characters.—Corallum simple, conical, and curved. The epitheca is stout, and marked with encircling lines and shallow annulations of growth. The calice is shallow and everted. The septa are lamellar, thin, numerous, and well developed, and at their inner ends they are a third of the total diameter of the corallum from the latro-dorsal side. They then curve and fold round upon each other, from which I take the specific name. In a section ten lines in diameter, there are forty-four primary, alternating with an equal number of secondary septa; the latter extend inwards for about a half of a line on the dorsal side, while on the ventral side of the corallum they are hardly recognisable, and represented by minute pointed granules, and each is united by rectangular interseptal dissepiments, which are few in number. The fossula is large, deep, and extends inwards to the centre of the visceral chamber, and a portion of the primary septa fold round, and form its walls on the ventral side of the corallum.

Height of corallum, 1 inch, 10 lines; diameter of calice, 1 inch, 1 line.

Formation, Carboniferous; Locality.—Found associated with Lithostrocian junceum in the upper thin bands of limestone and shale which characterise the upper portion of the lowest beds of carboniferous limestone, at Brockley, Lesmahagow, Lanarkshire.

Zaphrentis tuberculatis. Thomson. Sp. nov.

Plate IV., Figs. 5, 5A.

Specific Characters.—Corallum simple, turbinate, and curved. The epitheca is thin, and marked with encircling stria, and irregular annulations of growth. There are longitudinal ribs, and irregularly-dispersed tubercles. The calice is shallow and circular. The septa are smaller, and do not reach the centre of the visceral chamber on the dorsal side of the corallum, while on the ventral side they converge inwards to the centre of the central area. In a transverse section four and a half lines in diameter there are twenty-four primary septa, and the secondary septa are hardly recognisable. They are represented by minute pointed denticles, and each is united by sparse rectangular interseptal dissepiments. The tabulæ occupy the central area, and are inclined downwards to the ventral side of the corallum, and the interseptal area is occupied by large convex cells, convexity pointing upwards and outwards. The fossula is small, and situated on the dorsal side of the corallum. and one of the primary septa, of shorter length than the others, extends into it. There are two lateral depressions or (pseudo-fossula) extending into the centre of the central area.

Height of corallum, 1 inch; diameter of calice, 8 lines.

Formation, Carboniferous; Locality.—Found associated with Lithostrocian junceum in beds of shale that is interstratified with the thin bands of limestone which characterise the upper portion of the section of the lower members of the marine limestone, at Brockley, Lesmahagow, Lanarkshire.

Zaphrentis granulatis. Thomson. Sp. nov.

Plate IV., Figs. 6, 6A.

Specific Character.—Corallum simple, tall, and cylindro-conical. The epitheca is stout and marked with crenulate encircling stria and irregular annulations of growth, and there are numerous granules all over its surface. The calice is (imperfect) circular, and moderately deep. The septa are well developed, and extend to the centre of the visceral chamber, and in this respect is the nearest ally to the genus Densyphyllum Dybowski. In a transverse section four lines in diameter there are twenty-six septa, and each is united by spatse rectangular interseptal dissepiments. The fossula is narrow, and extends into the centre of the central area, and one of the septa, half the length of the others, extends into it.

Height of corallum, 1 inch 3 lines; diameter of calice, 6 lines.

Formation, Carboniferous; Locality.—Found in a dark arana ceous shale that overlies the lowest beds of marine limestone, at Charleston, Fifeshire.

This species is closely allied to *Zaphrentis Smithii*, Thomson, but is readily distinguished from that species by the possession of stouter septa, which converge to the centre of the visceral chamber, the smaller fossula, and the dense granular structure of the epitheca, from which I take the specific name. In the arrangement of the septa it approaches so closely to the structural details of Densyphyllum Dybowski, that I had great doubts whether it ought not to be classed amongst that group. When they fall to be considered, it however possesses characteristics that ally it to the genus *Zaphrentis*, and may be regarded as a passage from between these two genera.

Zaphrentis spinulosa. Edwards and Haime.

Plate IV., Figs. 7, 7A, 7B.

Specific Characters.—Corallum simple, turbinate, and curved. The epitheca is moderately stout, and marked with irregularly-dispersed spines and irregular and broad annulations of growth. The calice is circular and shallow. The septa do not reach to the centre of the visceral chamber; they stop short of the centre at about a-fourth of the total diameter of the corallum, and the centre is occupied with a flat tabula. In a transverse section five and a half lines in diameter there are twenty-eight primary septa, which alternate with an equal number of secondary septa. The latter are in the form of minute denticles, and each is united by sparse rectangular interseptal dissepiments. The fossula is small, and one of the primary septa, of greatly shorter length than the others, extends into it. In the longitudinal section the tabulæ are irregular, and are deflected downwards to the ventral side of the corallum, and there are seven interlamellar striæ in the space of a line, which pass inwards and acutely downwards.

Height of corallum, 1 inch; diameter of calice, 7 lines.

Formation, Carboniferous; Locality.—Found in thin beds of shale that are interstratified with thin bands of limestone that overlie the productus limestone, at Brockley, Lesmahagow, Lanarkshire.

Zaphrentis bicentrica. Thomson. Sp. nov.

Plate IV., Figs. 8, 8A, 8B, 8C.

Specific Characters.—Corallum simple, small, trochoid, and curved. The epitheca is thin, and marked with encircling stria, and shallow, broad annulations of growth, and there are spinous protuberances dispersed over its surface. The calice is circular and deep. The septa are irregularly developed. Those on the dorsal side are short, and extend inwards less than a third of the total diameter of the corallum, while those on the ventral side extend beyond the centre of the central area, and curve round and form the walls of the fossula. In a transverse section five and a half lines in diameter there are twenty-six primary septa, and the secondary septa are hardly recognisable. They are minute, and bend towards the primary and become attached, and form a minute angular cells at their junction with the periphery, and each is united by remote interseptal dissepiments. The fossula is large, and situated on the dorsal side, and extends inwards for two-thirds of the total diameter of the corallum, and two of the primary septa, of greatly shorter length than the others, extends into it.

Height of corallum, 8 lines; diameter of section, 4½ lines.

Formation, Carboniferous; Locality.—Found in beds of shale that are interstratified with the thin beds of limestone that overlie the productus limestone, at Brockley, Lesmahagow, Lanarkshire.

This species is readily distinguished from any of the tuberculated forms by the possession of a deep and large calice, the short and stout septa in the dorsal side of the corallum, and from *Zaph. denticulata* by the greater development of the tubercules on the epitheca and the arrangement of the septa.

Zaphrentis pachysepta. Thomson. Sp. nov.

Plate IV., Fig. 9.

fic Characters.—Corallum simple, small, conical, and curved.
itheca is stout, and marked with shallow annulations and
ır lines of growth. The calice is circular and moderately
The septa are thick, and on the dorsal side of the corallum
ɘ curved, and coalesce at the inner extremity of the deep
and on the ventral side they converge inwards, bend to,
ınd, and form its walls. In a transverse section five lines
eter there are twenty-six septa which are united by sparse,
ct, interseptal dissepiments. The fossula is large, and
a little beyond the centre of the visceral chamber, and three
epta, half the length of the others, extend into it. There
lateral depressions, and a septum of shorter length extends
ım both.

ht of corallum, 1 inch; diameter of calice, 6 lines.

ıation, Carboniferous; Locality.—Found in arenaceous
ıat overlies the lowest bed of marine limestone, at Charles-
feshire.

species is readily distinguished from all the other species
genus by its thick septa and by the form and arrangement
fossula.

Zaphrentis centralis. Edwards and Haime.

Plate IV., Figs. 10, 10A, 10B, 10C.

ific Characters.—Corallum simple, conical, and curved. The
a is moderately stout, and marked with encircling lines, and
irregular annulations of growth and longitudinal ribs. The
s circular, and moderately deep. The septa are lamellar in
er margins, and become single and delicate as they approach
ıtre of the visceral chamber; then they coalesce and form
, and the central septum of each group extends inwards, and
ı the centre of the central area. In a section nine lines in
er there are thirty-four primary septa, and the secondary
ıre represented by minute denticles, and each is united by
angular interseptal dissepiments. The fossula is large, and

situated on the ventral side of the corallum, and extends to the centre of the visceral chamber, and one of the primary septa extends one line into it.

Height of corallum, 2 inches; diameter of calice, 11 lines.

Formation, Carboniferous; Locality.—Found in shale that overlies the lowest bed of limestone, at Broadstone, Beith, Ayrshire.

Zaphrentis clavatis. Thomson. Sp. nov.

Plate IV., Figs. 11, 11A.

Specific Characters.—Corallum simple, small, and turbinate. The epitheca is thin, and marked with encircling stria and irregular shallow annulations of growth, and there are prominent tubercules sparsely distributed over its surface. The calice is circular and shallow. The septa are well developed, and extend to near the centre of the visceral chamber. At their outer margin they are thin, and stout towards their inner ends, and assume a more or less clavate form, from which I take the specific name. In a transverse section five and a half lines in diameter there are twenty-six primary, which alternate with an equal number of secondary septa. The latter extend inwards from the periphery for about half a line, and each is united by rectangular interseptal dissepiments. The fossula is large, and extends into the centre of the central area, and a septum, of half the length of the others, extends into it.

Height of corallum, 10 lines; diameter of section, 5 lines.

Formation, Carboniferous; Locality.—Found in shale that is interstratified with thin bands of limestone that overlie the productus limestone, at Brockley, Lesmahagow, Lanarkshire.

This species is readily distinguished from *Zaphrentis tuberculata* by the larger septal fossula and the clavate aspect of the septa.

Zaphrentis Konincki. Edwards and Haime.

Plate IV., Figs. 12, 12A.

Specific Characters.—Corallum simple, small, conical, and curved. The epitheca is stout, and marked with encircling stria and shallow annulations of growth and longitudinal ribs. The calice is circular and deep. The septa are lamellar and stout, and converge inwards and fold round the inner extremity of the fossula in the centre of the visceral chamber. In a section four and a half lines in diameter there are thirty primary, and these alternate with an equal number of secondary septa. The latter extends inwards from the periphery for a third of a line, and each is united by rectangular interseptal dissepiments. The fossula is narrow and extends into the centre of the central area, and one of the septa, of shorter length than the others, extends into it.

Height of corallum, 10 lines; diameter of calice, 6 lines.

Formation, Carboniferous; Locality.—Found in a bed of shale that overlies the bed in which *Streptorhynchus crenestrea* is found abundant, in Auchenskeoch, Dalry, Ayrshire.

Zaphrentis echinatis. Thomson. Sp. nov.

Plate IV., Figs. 13, 13A.

Specific Characters.—Corallum simple, cylindro-conical, and curved. The epitheca is stout, and marked with encircling lines and broad annulations of growth, and near the base of the corallum there are a number of irregularly-dispersed obtuse spine processes. The calice is deep and the septa are stout, and on the dorsal side they converge inwards to near the centre of the visceral chamber, where they coalesce and form a dense vertical wall of sclerenchyma on the dorsal side of the central area. The septa are of two orders. There are thirty primary, which alternate with an equal number of secondary septa. The latter are sharp spine-like processes, and extend inwards for two-thirds of a line from the periphery, and each is united by sparse and rectangular interseptal dissepiments. The fossula is large, and converges to near the centre of the central area, and one of the primary septa, half the length of the others, extends into it. The central area is a small, flat, hollow depression, and surrounded by the wall formed by the union of the inner ends of the septa.

Height of corallum, 1 inch 9 lines; diameter of calice, 11 lines.

Formation, Carboniferous; Locality. — Found in the shale that overlies the lowest bed of limestone, at Charleston, Fifeshire.

Zaphrentis amphitheca. Thomson. Sp. nov.

Plate IV., Figs. 14, 14A, 14B, 14C.

Specific Characters.—Corallum simple, small, trochoid, and [illegible]ad curved. The epitheca is moderately stout and marked with [illegible]th encircling stria, shallow annulations of growth, and stout costal [illegible]al ribs. The calice is circular and moderately deep. The septa are [illegible] are lamellar, and at their inner ends the lamellæ curve round the [illegible]he interseptal space, and bend inwards, and form the lamellæ of the [illegible]he neighbouring septum, and representing a series of deep convolu[illegible]lutions, and thus form a pseudo-mesotheca; and the inter[illegible]erlamellar spaces are open at their outer extremities, leaving an open[illegible]n, free communication with the intertheeal space, and presents [illegible] a double wall. At the angle of each fold there is a minute vertica[illegible]l plate, which passes from the inner to the outer wall, thu[illegible]us representing a series of minute intertheeal vertical cells. Th[illegible]e fossula is large and deep, and the inner ends of the septa fol[illegible]d round and form its walls; and its width is a fourth of the tota[illegible]l diameter of the corallum; and it extends across the centre of th[illegible] visceral chamber for nearly three-fourths of its total diameter.

Height of corallum, 8½ lines; diameter of calice, 5 lines.

Formation, Carboniferous; Locality.—Found in shale that is interstratified with the thin beds of limestone near the base of the carboniferous system, at Brockley, Lesmahagow, Lanarkshire.

This remarkable species differs so widely from all the other species of the genus, in the possession of the double wall and the vertical plates in the intertheeal space, that I did regard it as possessing characters of generic distinction. But the deep fossula, and from the fact that the inner ends of the septa fold round and form its walls, as in *Zaphrentis* proper, allied it so closely, and which I believe to be the character of primary importance in the definition of the genus, induced me to abandon the creation of a new genus for it and allied forms. And, therefore, I regard the double wall as only sufficiently distinct for the specific name.

Zaphrentis vermicularis. De Koninck.

Plate IV., Fig. 15.

Specific Characters.—Corallum simple, small, conical, and curved. The epitheca is thin, and marked with encircling stria and shallow annulations of growth and longitudinal ribs. The calice is circular, shallow, and everted. The septa are delicate and well developed. They unite in bundles of four and five near their inner ends, and five of the central ones of each bundle converge to the dorsal side of the corallum, and then unite, and assume a pentagonal stellate aspect. In a transverse section fully three lines in diameter there are twenty-two septa of unequal length. There is no interseptal dissepiments visible. The fossula is large, and extends beyond the centre of the visceral chamber to the dorsal side of the corallum.

Height of corallum, 5 lines; diameter of calice, 4 lines.

Formation, Carboniferous; Locality.—Found in the thin bands of shale that are interstratified with the thin beds of limestone which characterise the upper portion of the lower members of the marine series of that system in Scotland, at Brockley, Lesmahagow, Lanarkshire.

Zaphrentis cyathina. De Koninck.

Plate IV., Figs. 16, 16A, 16B, 16C.

Specific Characters.—Corallum simple, conical, cylindro-conical, and curved. The epitheca is stout, and marked with encircling stria, and shallow annulations of growth, and longitudinal ribs. The calice is circular and moderately deep. The septa are lamellar and converge inwards, and on the latro-ventral side they gently bend, unite, and fold round the inner end of the fossula. In a section, four and a-half lines in diameter, there are twenty primary septa, and the secondary septa are hardly recognisable. They are represented by obtuse conical granules. The interseptal dissepiments are indistinct and few in number. The fossula is large, and situated on the latro-ventral side of the corallum, and extends into the centre of the visceral chamber, and at its inner margin it is somewhat broader than towards the outer extremity, and one of the septa, of shorter length than the others, extends into it.

Height of corallum, 8 lines; diameter of calice, 5 lines.

Formation, Carboniferous; Locality.—Found in the shale that overlies the uppermost marine limestone of the system at Gare, Carluke, Lanarkshire; and in arenaceous shale that overlies the lowest beds of marine limestone of the series at Charleston, Fifeshire.

Zaphrentis intermedia. De Koninck.

Plate IV., Fig. 17, 17A.

Specific Characters.—Corallum simple, small, and conical. The epitheca is moderately stout, and marked with encircling stria, [illegible], and shallow annulations of growth, and longitudinal ribs. The calice is deep and circular. The septa stop short of the centre of [illegible] of the visceral chamber. In a transverse section four lines in diameter there are twenty primary septa, and these alternate with an equal number of secondary septa, the latter are small, [illegible], and extend inwards from the periphery for about a third of a line, the interseptal dissepiments are sparse, the fossula is large, and one of the primary septa, half the length of the others, extends into it.

Height of corallum, 7 lines; diameter of calice, 4 lines.

Formation, Carboniferous; Locality.—Found in a bed of shale that overlies the upper marine limestone of the carboniferous system in Scotland, at Gare, Carluke, Lanarkshire.

Zaphrentis Omaliusi. Edwards and Haime.

Plate IV., Figs. 18, 18A.

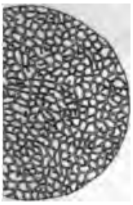
Specific Characters. — Corallum simple, cylindro-conical, and curved. The epitheca is stout, and marked with crenulate encircling stria and irregular annulations of growth and costal ribs. The calice is circular and deep. The septa converge to the centre of the visceral chamber on the ventral side, and fold round and form the walls of the fossula, whilst those on the dorsal side stop short of the centre, and at their inner ends there is a sub-central cell, obovate in outline, and the inner end of the septa are attached to its wall. In a transverse section four lines in diameter there are twenty-four septa, and each is united by sparse rectangular interserseptal dissepiments. The fossula is narrow, and extends into the centre of the central area.

Height of corallum, 1 inch 1 line; diameter of section, 4 lines.

Formation, Carboniferous; Locality.—Found in a bed of arenaceous shale that is superimposed upon the lowest bed of marine limestone, at Charleston, Fifeshire.

This species is distinguished from *Zaphrentis intermedia* by the thicker wall, and the septa do not meet, but are attached to the central cell in the centre of the visceral chamber.

1A



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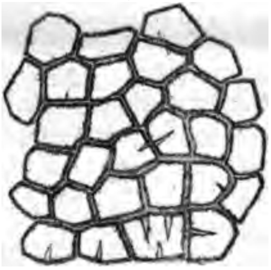
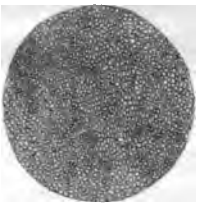


Fig. 1



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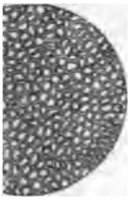

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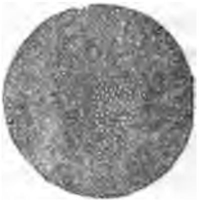

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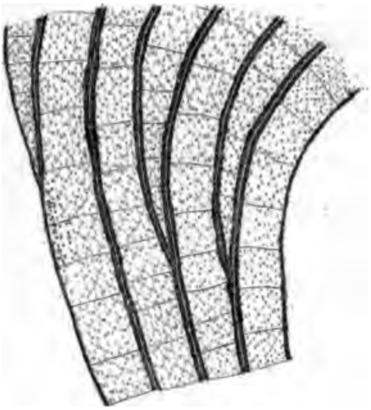

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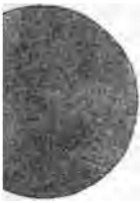

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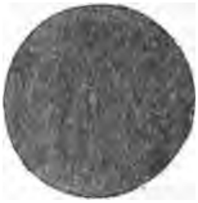

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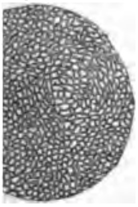

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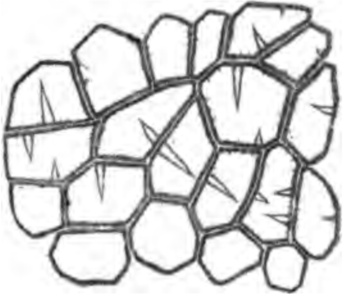

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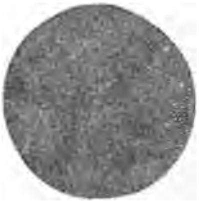

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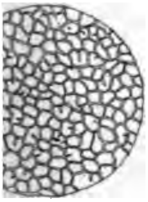

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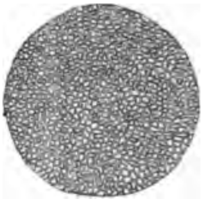

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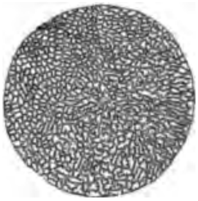

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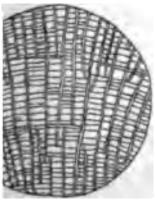

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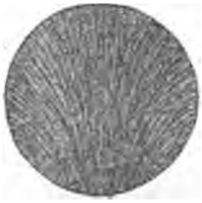

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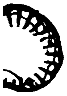

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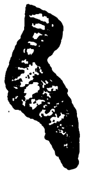

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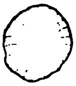
2 A

4 A



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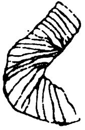

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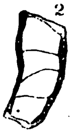

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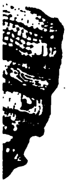

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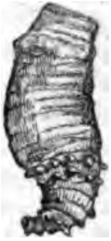

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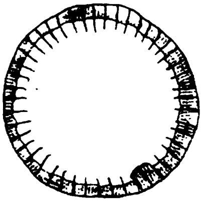
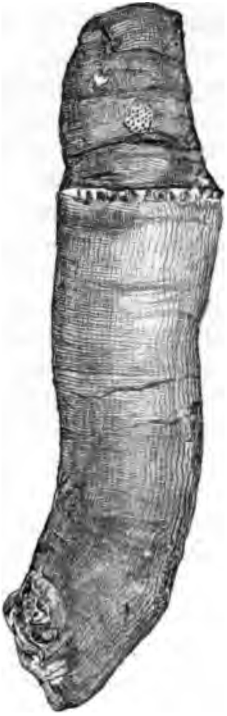


Fig. 1



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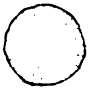

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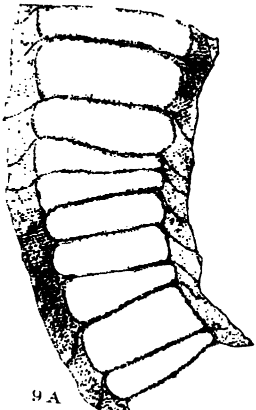

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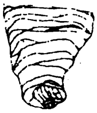

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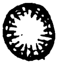

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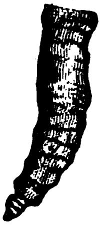
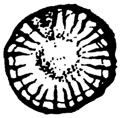


9 A

7 C



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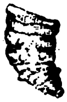

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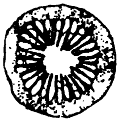

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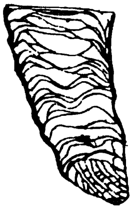

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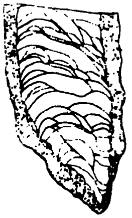

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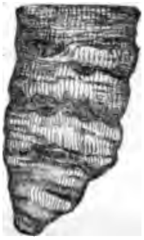

Robert Gardner & Co. lith.

EXPLANATION OF PLATES.

PLATE I.

ig. 1.—*Alveolites septosa*. Edwards and Haime. A transverse section, natural size.

„ 1A.—A transverse section of the same, magnified three diameters.

„ 2.—*Alveolites septosa*. Edwards and Haime. A transverse section of the granular variety, from Dunbar, from same locality as Dr. Fleming's type specimen.

„ 2A.—A transverse section of the same, magnified three diameters.

„ 3.—A transverse section of the same, enlarged twelve diameters.

„ 4.—*Alveolites depressa*. Edwards and Haime. A transverse section, natural size.

„ 4A.—A transverse section of the same, enlarged three diameters.

„ 5.—*Alveolites capillaris*. Phillips. A transverse section, natural size.

„ 5A.—A transverse section of the same, enlarged three diameters.

„ 6.—*Alveolites Etheridgii*. Thomson. Sp. nov. A transverse section, natural size.

, 6A.—A transverse section, enlarged three diameters.

, 6B.—A longitudinal section of the same, natural size.

, 6C.—A longitudinal section, enlarged three diameters.

, 6D.—A transverse section of the same, natural size, showing the vermicular and tubercular structure in one portion of the section, whilst in another part of the same corallum those peculiarities of structure are totally wanting.

, 7.—A longitudinal section greatly enlarged, to show the granular structure and the arrangement of the mural pores.

, 8.—A transverse section, greatly enlarged.

PLATE II.

ig. 1.—*Amplexus coralloides*—Sowerby—showing outline and external aspect of the corallum. Lower carboniferous, Broadstone, Beith, Ayrshire.

„ 1A.—A transverse section of the same.

„ 1B.—A longitudinal section of the same.

„ 2.—*Amplexus Sowerbii*. Phillips. A longitudinal section.

„ 2A.—A transverse section of the same, natural size. Lower carboniferous, Auchenskeoch, Dalry, Ayrshire.

„ 3.—*Amplexus serpuloides*. De Koninck,

„ 3A.—A longitudinal section of the same, natural size.

„ 3B.—A transverse section of the same, natural size. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.

„ 4.—*Amplexus nodulosus*. Phillips.

„ 4A.—A transverse section of the same, natural size.

„ 4B.—A longitudinal section of another specimen, natural size.

Fig. 4c.—A transverse section of the same, natural size. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.
,, 5.—*Amplexus spinosus.* De Koninck.
,, 5A.—A transverse section of the same, natural size.
,, 5B.—A longitudinal section of another specimen, natural size.
,, 5C.—A transverse section of the same, natural size. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.
,, 6.—*Amplexus irregularus.* Thomson. Sp. nov., natural size.
,, 6A.—A transverse section of the same, natural size.
,, 7.—*Amplexus corniformus.* Ludwig.
,, 7A.—A transverse section of the same, natural size.
,, 7B.—A longitudinal section of another specimen, natural size.
,, 7C.—A transverse section of the same, natural size. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.
,, 8.—*Amplexus Haimeanus.* De Koninck, natural size.
,, 8A.—A transverse section of the same, natural size.
,, 9.—Another specimen of the same, natural size.
,, 9A.—A transverse section of the same, natural size, in which the septa are longer, and the interseptal dissepiments are more numerous. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.
,, 10.—*Amplexus Henslowi.* Edwards and Haime.
,, 10A.—A transverse section of the same, natural size.
,, 10B.—A longitudinal section of the same, natural size. Lower carboniferous, Broadstone, Beith, Ayrshire.

PLATE III.

Fig. 1.—*Zaphrentis Enniskilleni.* Edwards and Haime.
,, 1A.—A transverse section of the same. This section is cut about [illegible] 16th of an inch above the superior tabula, consequently there are no interseptal dissepiments represented.
,, 1B.—A transverse section of the same, natural size, and cut half [illegible] inch below the floor of the calice.
,, 1C.—A transverse section of the same, cut one inch below the floor of the calice.
,, 1D.—A transverse section of the same, cut one and a-half inch below [illegible] floor of the calice.
,, 1E.—A transverse section of the same, cut two inches below the floor of the calice. Lower carboniferous, Roughwood, Beith, Ayrshire.*

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* I have represented sections from different parts of the corallum of this species, also [illegible] Fig. 3, in order to show that the structural characters are continuous from the superior [illegible] the inferior extremities of each (unless in the case of abnormal or passage forms), and [illegible] show that no reliance can be placed in an assertion recently made—*i.e.*, that different species can be created by making sections at different parts of the same corallum—a result that I have not been able to accomplish.

-*Zaphrentis Griffithi*. Edwards and Haime. A transverse section, showing the large fossula, extending to the centre of the visceral chamber, and cut a little below the floor of the calice.

—A transverse section of a smaller specimen, cut midway between the floor of the calice and the base of the corallum. Lower carboniferous, Charleston, Fifeshire.

-*Zaphrentis patula*. Michelin. A transverse section, cut immediately below the floor of the calice.

—A transverse section of the same, cut one half of an inch further down.

—A transverse section of the same, cut one half of an inch below 3A.

—A transverse section of the same, cut one half of an inch below the preceding.

.—A transverse section of the same, cut one half of an inch below the preceding. Lower carboniferous, Roughwood, Beith, Ayrshire.

-*Zaphrentis Bowerbanki*. Edwards and Haime. A longitudinal section, showing the arrangement of the tabulæ, and the cellular tissue that is exposed in the longitudinal and also in the transverse sections at the inner ends of the septa and around the inner extremity of the fossula in the centre of the visceral chamber.

—A transverse section of the same, cut a little below the floor of the calice.

—A transverse section of another specimen, cut fully a quarter of an inch below the floor of the calice.

—A transverse section of another specimen, cut one quarter of an inch below the floor of the calice.

.—A trasverse section of another specimen, cut a quarter of an inch from the base of the corallum. Lower carboniferous, Shields, East Kilbride, Lanarkshire.

—*Zaphrentis Guerangeri*. Edwards and Haime. A longitudinal section, showing the irregular tabulæ, and the large interseptal tissue around the periphery.

.—A transverse section of the same, cut immediately below the floor of the calice. Lower carboniferous, Auchenskeoch, Dalry, Ayrshire.

All the sections in this Plate are natural size.

Plate IV.

—*Zaphrentis Edwardsiana*. De Koninck.

.—A transverse section of the same, cut just below the floor of the calice. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.

—*Zaphrentis Cliffordana*—Edwards and Haime—showing everted calice.

Fig. 2A.—A transverse section of the same, cut immediately below the floor of the calice, showing the small fossula and the cellular tissue in the centre of the visceral chamber, and the pseudo-fossula on either side of the corallum, and at right angles to the inner end of the fossula. Lower carboniferous, Boghead, Hamilton, Lanarkshire.

,, 3.—*Zaphrentis Phillipsi*. Edwards and Haime. A transverse section, cut one line below the floor of the calice.

,, 3A.—A transverse section of the same, cut a little below the floor of the calice. This specimen is somewhat smaller than the preceding. Lower carboniferous, Auchenskeoch, Dalry, Ayrshire.

,, 4.—*Zaphrentis curvulina*. Thomson. Sp. nov. A transverse section, cut about a quarter of an inch below the floor of the calice. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.

,, 5.—*Zaphrentis tuberculatis*. Thomson. Sp. nov.

,, 5A.—A transverse section of the same, cut immediately below the floor of the calice. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.

,, 6.—*Zaphrentis granulatis*. Thomson. Sp. nov.

,, 6A.—A transverse section of the same, cut one quarter of an inch below the floor of the calice. Lower carboniferous, Charleston, Fifeshire.

,, 7.—*Zaphrentis spinulosa*. Edwards and Haime.

,, 7A.—A transverse section of the same, cut a little below the floor of the calice.

,, 7B.—A longitudinal section of the same, showing the tabula bent down to the dorsal side of the corallum. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.

,, 8.—*Zaphrentis bicentrica*. Thomson. Sp. nov.

,, 8A.—A transverse section of the same, cut immediately below the floor of the calice.

,, 8B.—A small specimen of the same.

,, 8C.—A transverse section of same, cut a little below the floor of the calice. Lower carboniferous. Brockley, Lesmahagow, Lanarkshire.

,, 9.—*Zaphrentis pachyspta*. Thomson. Sp. nov. A transverse section, showing the remarkable fossula extending inwards beyond the centre of the visceral chamber, and the two lateral pseudo-fossula. Lower carboniferous, Charleston, Fifeshire.

,, 10.—*Zaphrentis centralis*. Edwards and Haime.

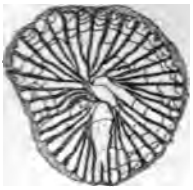
,, 10A.—A transverse section of the same, cut immediately below the floor of the calice.

,, 10B.—A transverse section of another specimen, cut just below the floor of the corallum.

,, 10C.—A transverse section of another specimen, cut about a quarter of an inch below the floor of the calice. Lower carboniferous, Broadstone, Beith, Ayrshire.

,, 11.—*Zaphrentis clavatis*. Thomson. Sp. nov.

2



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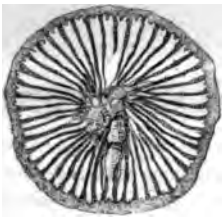

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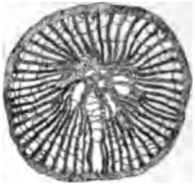

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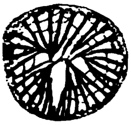

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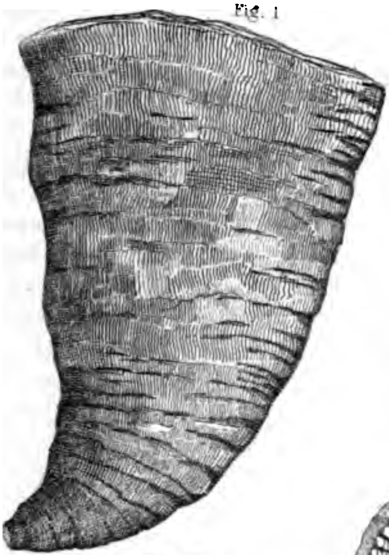

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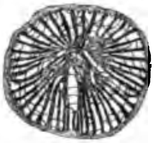

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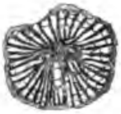

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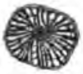

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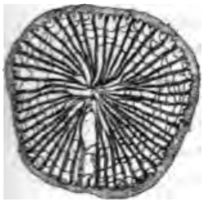

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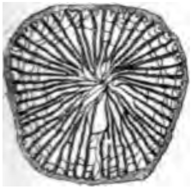

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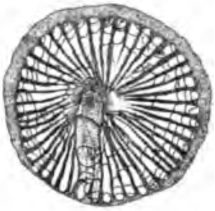

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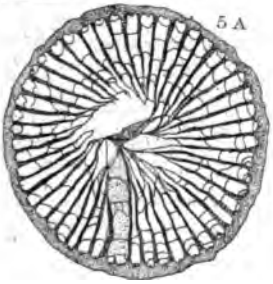

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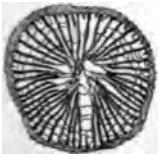

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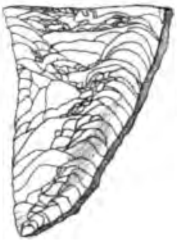

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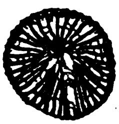

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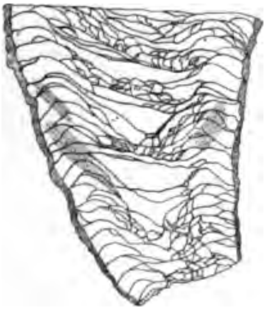

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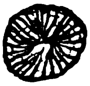

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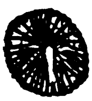

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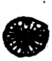

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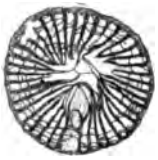

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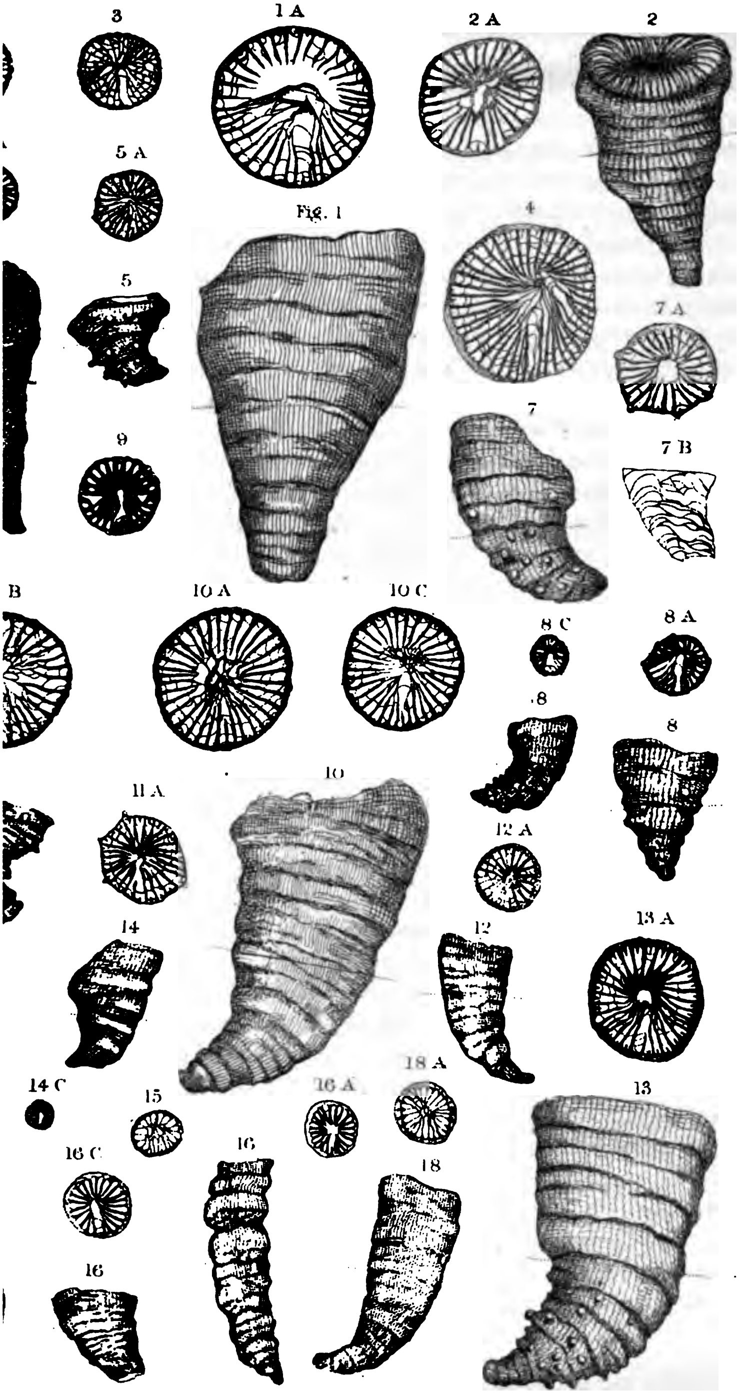
Proceedings Phil. Soc. of Glasgow. Plate IV



Robert Gardner & [illegible] Lith.

Fig. 11A.—A transverse section of the same. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.

,, 12.—*Zaphrentis Konincki.* Edwards and Haime.

,, 12A.—A transverse section of the same, cut a little below the floor of the calice. Lower carboniferous, Auchenskeoch, Dalry, Ayrshire.

,, 13.—*Zaphrentis echinatis.* Thomson. Sp. nov.

,, 13A.—A transverse section of the same, cut a quarter of an inch below the floor of the calice. Lower carboniferous, Charleston, Fifeshire.

,, 14.—*Zaphrentis amphitheca.* Thomson. Sp. nov.

,, 14A.—A transverse section, cut a little below the calice.

,, 14B.—A small specimen of the same.

,, 14C.—A transverse section of the same, cut just below the floor of the calice. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.

,, 15.—*Zaphrentis vermicularis.* De Koninck. A transverse section of the same, cut below the floor of the calice. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.

,, 16.—*Zaphrentis cyathina.* De Koninck.

,, 16A.—A transverse section of the same, cut a little below the floor of the calice. Lower carboniferous, Charleston, Fifeshire.

,, 16B.—A specimen of the same.

,, 16C.—A transverse section cut a little below the floor of the calice. Upper carboniferous limestone, Gare, Carluke, Lanarkshire.

,, 17.—*Zaphrentis intermedia.* De Koninck.

,, 17A.—A transverse section of the same, cut a little below the floor of the calice. Upper carboniferous limestone, Gare, Carluke Lanarkshire.

,, 18.—*Zaphrentis Omaliusi.* Edwards and Haime.

,, 18A.—A transverse section of the same, cut a little below the floor of the calice. Lower marine limestone, Charleston, Fifeshire.

All the above sections in this Plate are natural size.

MINUTES OF SESSION.

November 3rd, 1880.

The Session of the Philosophical Society of Glasgow was opened this evening at Eight o'Clock, in the Society's New Buildings, 2[illegible]07 Bath Street. Dr. Andrew Fergus, President, in the Chair.

The Minutes of the Meeting of the Society held on 5th May, 1880, with that of the Extraordinary General Meeting held on 17th June, having been printed in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairman.

The following were proposed as Members, viz.:—

Mr. Hugh M'Culloch, House Painter, 102 West Regent Street. Recommended by Mr. H. K. Bromhead, Dr. Fergus, and Dr. M'Vail.

Mr. T. Graham Young, Kelly, Wemyss Bay. Recommended by Prof. James Thomson, Sir William Thomson, and Prof. John Ferguson.

Mr. George Stuart, Merchant, 21 Royal Exchange. Recommended by Mr. John Mann, Dr. Fergus, and Dr. M'Vail.

Mr. John M. Shaw, Ironmonger, 14 Union Street. Recommended by Mr. John Kirsop, Mr. Archibald Robertson, and Mr. John Mann.

Mr. A. P. Henderson, Engineer and Shipbuilder, 10 Crow[illegible]w Terrace, Dowanhill. Recommended by Mr. J. J. Coleman, Mr. E. M. Dixon, and Mr. John Robertson.

Mr. Hugh Paton, Warehouseman, 61 Miller Street. Recommended by Dr. Wallace, Dr. Stirton, and Dr. Clark.

Mr. Walter E. Wingate, 4 Bowmont Terrace. Recommended by Mr. John Kirsop, Mr. John Robertson, and Mr. John Mann.

Mr. William Fife, Commission Merchant, 52 Glassford Street. Recommended by Mr. Michael Connal, Mr. John Kirsop, and Mr. Robert Westlands.

Jas. T. Bottomley, M.A., F.R.S.E., F.C.S., Demonstrator ıral Philosophy, University of Glasgow, 2 Eton Terrace. ıended by Sir Wm. Thomson, Prof. Jas. Thomson, and John Vincent Day.

William Bottomley, Jun., C.E., University. Recom- by Sir Wm. Thomson, Prof. Jas. Thomson, and Mr. St. incent Day.

Archibald Brownlie, Writer, 225 West George Street. ıended by Dr. Muirhead, Mr. A. C. Hunter, and Mr. John on.

David Maclure, Letterpress Printer, 62 Argyle Street. ıended by Mr. James C. Wyper, Mr. Archd. Robertson, . John Robertson.

ieorge Smellie, Measurer, 107 Bath Street. Recommended Archd. Robertson, Mr. John Mann, and Mr. John on.

ames Brand, Civil Engineer and Contractor, 123 Hope Recommended by Mr. Jas. C. Wyper, Mr. Archd. on, and Mr. John Robertson.

Wallace Fairweather, C.E., Patent Agent, 96 Buchanan Recommended by Dr. Fergus, Mr. John Robertson, and :hd. Robertson.

). A. Black, Sharebroker, 214 Bath Street. Recommended R. Easton, Mr. A. Dow Dixon, and Mr. John D. Thomson.

ollowing were elected Members of the Society, viz.:—

ames Young, Jun., Kelly, Wemyss Bay.

Alex. S. Wilson, M.A., B.Sc., Professor of Botany, ın's College.

Alexander W. Donald, Colliery Salesman, Bank Place, lang.

ohn Fowler, Builder, Kelvinbank Terrace, 4 Gray Street, rd.

Iugh Reid, Engineer, 10 Woodside Terrace.

ames Reid, Jun., Engineer, 10 Woodside Terrace.

ohn Sutherland, Greenbrae, Pollokshields.

)avid Sutherland, Jun., Greenbrae, Pollokshields.

ergus, the President, delivered an Opening Address—"On ly History of the Society"—the very interesting materials h were derived mainly from the records of the first five years of the Society's existence (1802-1807), as contained in the first Minute Book of the Society. The Book was laid on the table. The President further stated that he had prepared more material than he could submit at one Meeting, and would be ready, if the Society wished it, to continue the subject from time to time as opportunity might offer. On the motion of Dr. Wallace, the thanks of the Society were unanimously awarded to Dr. Fergus for his address, and he was requested to lay before the Society at future Meetings the materials he had prepared.

The President stated that Mr. E. M. Dixon had, a short time ago, resigned the Secretaryship of the Society on account of his duties in connection with Allan Glen's Institution; that the Council had appointed Mr. John Robertson Secretary *ad interim*, and had remitted the whole question of the Secretaryship to be considered by a Committee of the Council; that a Report by that Committee had been received and adopted by the Council, which was then read as their recommendation on the subject.

Mr. James Thomson, F.G.S., moved, and Mr. George Watson seconded, the adoption of the said Report by the Society.

Mr. James Thomson then moved, and Mr. George Watson seconded the motion, that five Members of the Society be appointed to meet with five Members of the Council, to consider the Report, and advise as to the best mode of carrying it out.

The following five gentlemen were then nominated to form the Committee on the part of the Society, viz.:—Mr. George Watson, Mr. James Thomson, Mr. Nathaniel Dunlop, Mr. James Millar, and Dr. Hugh Thomson.

Mr. Archibald Hewat and Mr. Alex. S. Baird were appointed Auditors of the Treasurer's Accounts for the past Session.

(Signed) ANDW. FERGUS.

November 17th, 1880.

The Seventy-ninth Annual General Meeting of the Philosophical Society of Glasgow, for the Election of Office-Bearers and other Business, was held this evening at Eight o'clock, in the New Buildings, 207 Bath Street. Dr. Andrew Fergus, President, in the Chair.

he Minutes of the last Meeting of the Society, having been ted in the notice calling this Meeting, were held as read, and e confirmed and signed by the Chairman.

he following were proposed as Members, viz.:—

r. William Campbell, Assessor, 24 Ingram Street. Recom- ded by Mr. John Mann, Dr. James B. Russell, and Dr. rew Fergus.

r. James Fleming, Earthenware Manufacturer, 7 Fitzroy e. Recommended by Dr. Eben. Duncan, Mr. John Mann Mr. John Robertson.

r. John Harvie, Secretary, Clydesdale Bank, St. Vincent e. Recommended by Mr. John Mann, Mr. D. Nicol, and John Robertson.

r. Adam Elliot Black, C.A., F.C.S., Leabank, Crosshill. Recommended by Dr. Eben. Duncan, Mr. John Mann, and Mr. n Robertson.

r. William S. Pettigrew, 17 Queen's Crescent. Recommended Mr. J. D. Thomson, Mr. Alexander Scott, and Mr. John ertson.

r. R. H. Pinkerton, M.A., Mathematical Lecturer, Uni- ity, 46 Bank Street, Hillhead. Recommended by Mr. John Kerr, M.A., Mr. Thomas Muir, M.A., F.R.S.E., and Mr. John sop.

r. Michael Simons, 206 Bath Street. Recommended by Mr. n Mayer, F.C.S., Dr. Robt. Bell, and Mr. John M'Gavin.

r. M. Waddell, Ironmonger, 261 Argyle Street. Recom- ded by Mr. John Mayer, F.C.S., Dr. Robert Bell, and Mr. M'Gavin.

r. N. B. Cameron, Draper, Cambuslang. Recommended by Henry Muirhead, Mr. Michael Connal, and Dr. Andrew as.

John Robertson, Interim Secretary, read the Annual t by the Council on the state of the Society, which was ed and ordered to be printed in the *Proceedings*. The t was as follows:—

REPORT ON THE STATE OF THE SOCIETY, 1879-80.

BUILDINGS.—In presenting the Report on the Seventy-eighth Session Society, the Council congratulate the Members that the anticipation of last Report has been fulfilled, and that they have been enabled to open the Seventy-ninth Session in the New Rooms.

This building is the joint property of the Institution of Engineers and Shipbuilders of Scotland and the Philosophical Society of Glasgow. Contracts were concluded for its erection in May, 1879, and the work was commenced in the following month. The Contractors were as follows:—

Mason, Digger, and Brick Work, -	Bartley Dinsmore.
Wright Work, - - - - - -	David Guthrie & Co.
Plumber Work, - - - - - -	William Reid.
Slater Work, - - - - - -	John Morrison & Son.
Plaster Work, - - - - - -	James Craig & Son.
Ironfounder Work, - - - - -	Moses M'Culloch & Co.
Painter Work, - - - - - -	Hugh M'Culloch.
Glazier Work, - - - - - -	C. & J. Malloch.

The Architects were Mr. Thomas L. Watson and Mr. William J. Millar, C.E.

The Building comprises the following accommodation:—

On the Ground or Street Floor—Library and Reading Room.

On the First Floor—Council Room and Lecture Hall, seated for about 300.

On the Second Floor—Two Rooms for Sectional Meetings, one which serves for Council Room and as Library of the Architectural Section.

On an Entresol Floor over the Entrance Corridor—A Lavatory and a Store Room for books not much in use.

On the Basement Floor—Two large Rooms, two Fireproof Safes, Lavatory, Heating Chamber, and Janitor's House.

The whole Building is heated by means of hot water-pipes, each flat separately. It is fitted up in a very complete manner, and very comfortably furnished. It is expected to cost about £5,000, including price of ground and furniture; but as soon as the accounts have been closed, a detailed statement will be given.

The first Meeting was held by the Institution of Engineers and Shipbuilders in Scotland, in the Lecture Hall, on the evening of Tuesday, 2nd November, and this Society opened Session 1880-81 in it on the following evening. Previous to this, the Library and fittings had been removed from the Rooms in Sauchiehall Street, and the Library was ready for the use of the Members on the 13th of October. The Council expect that the change will result in increased efficiency in every department. Everything has been specially designed for the purposes of the Societies. The Lecture Hall is arranged so that diagrams, apparatus, and specimens of any sort can be fully exhibited to every Member of the audience, and so that the Lecturer can at the same time be perfectly seen and heard. Every convenience is also afforded for experiments—the table in the Lecture Hall being supplied with gas and water, and that in the Sectional Room with gas.

The Acting Building Committee consisted of six Members, of whom Dr. Wallace Mr. Archibald Robertson, and Mr. Honeyman represented this

Society. To the energy of this Committee, and especially to the untiring exertions of Mr. Archibald Robertson, it is due that the first Meeting of this Session was able to be held in these premises.

The Geological Society and the Natural History Society have been accommodated in the smaller Hall and Council Room, and their Meetings are now held there.

At a Joint-Meeting of the Councils of the Institution of Engineers and Shipbuilders and the Philosophical Society, the following Agreement was finally concluded between them :—

1st.—"The proprietorship being joint and equal, the details of management shall be under a Joint-Committee of six, to be elected annually, three from the Council of each Society, to be called the House Committee, who shall elect from their number their own Chairman, and shall have power o appoint a Secretary and Treasurer—three Members of this Committee to be a quorum.

2nd.—"Each Society shall have such use of the several Rooms as they may from time to time respectively require for their Meetings. The times f these Meetings shall be regulated by the House Committee, having egard to the present days of Meetings.

3rd.—"The Libraries of the Societies shall be kept distinct, but Members f each Society shall have access to the books of the other for consultation n the Library.

4th.—"So far as not required by either Society, the Rooms may be let y the House Committee, and the income derived from such letting shall applied towards defraying the joint expenses, such as wages, taxes, eating, lighting, &c., the balance of expenditure to be contributed in equal roportions by the two Societies.

"The Treasurer of the House Committee shall receive all payments due , and discharge all claims upon, the Societies in a joint capacity, the alance of expenditure over income to be contributed in equal proportions onthly by the two Societies; the accounts to be regularly audited by the uditors of both Societies, and copies furnished to the Council of each ociety.

5th.—"Any difference arising in the views of the House Committee shall referred to a Special Committee, then to be chosen, consisting of Ten embers from the Council of each Society—nine to be a quorum; and, ling agreement between them, it shall be referred for ultimate decision the Dean, for the time being, of the Faculty of Procurators in Glasgow."

A House Committee of six members has been appointed for the future agement of the Building—Dr. Wallace, Mr. Archd. Robertson, and John Kirsop, as representatives of the Council of this Society; and rs. Mansel, Jamieson, and Gale, on behalf of the Institution of gineers and Shipbuilders.

XI. *Membership.*—The number of Ordinary Members on the Roll at the inning of Session 1879-80, as per last Report, was 633. During the

Session, 41 new Members were admitted, making 674 in all. Of this number 18 have resigned; 2 have left Glasgow, their names being placed on the suspense list; 9 have died; and 9 have been struck off the Roll for non-payment of annual subscriptions; leaving on the Roll at the commencement of the present Session, 636. There are 17 Honorary Members—5 Foreign, [illegible] American and Colonial, and 9 British. The Corresponding Members are [illegible] There are 24 Life Members.

III. *Sections.*—The Sections have as usual furnished the Society with [illegible] important papers. Their Reports will be found in the *Proceedings.*

IV. *The Proceedings.*—The printed *Proceedings* of the Society for Session 1879-80 occupy 452 pages, exclusive of Index and Contents, and form Part I. of Volume 12. It is by far the largest part yet issued by the Society. It contains 19 papers, including 3 read before the Chemical Section.

V. *The Gas Exhibition.*—At an extra Meeting of the Society, held in May, it was agreed—in the event of the Exhibition Fund of 1847 in the hands of the Corporation being available as a guarantee—to hold an Exhibition of Gas Apparatus, &c., in connection with the Society. This was energetically carried out in October, and was highly appreciated by the public. As soon as the Committee have finally concluded their labours, a full Report of the Exhibition will be presented to the Society.

VI. *Mr. Napier's Legacy.*—The Council desire gratefully to acknowledge the receipt of a Legacy of £100 received during the Session, being a sum allocated by the Trustees of the late Robert Napier, Esq., of Shandon, who was a member of the Society, from the sum left by that gentleman for English and Scottish Institutions.

(Signed) JOHN ROBERTSON,
Interim Secretary.

The Audited Statement of Accounts for Session 1879-80, by Mr. Mann, the Treasurer, having been printed in the Circular calling the Meeting, was held as read, was approved of, and ordered to be printed in the *Proceedings*. Mr. Archibald Hewat, one of Auditors, suggested that a Capital Account should be formed, and that all subscriptions by Life Members should be added to that Account. He also called attention to the fact that the Account of Messrs. Maclay, Murray, & Spens, of £23 2s. 8d., consisted entirely of outlays, no professional fees being charged for work done in connection with the Incorporation of the Society. The President moved that the thanks of the Society be given to Messrs. Maclay, Murray, & Spens, and the motion was carried by acclamation.

Mr. John Robertson, Librarian, read the Annual Report on the Library, which was adopted, and ordered to be printed in the *Proceedings*. The Report was as follows:—

LIBRARY COMMITTEE'S REPORT, 1879-80.

The Library Committee have pleasure in reporting that the Library has been transferred to the new premises. In the beginning of July the presses were taken over and put up, with the necessary additions and changes. On the 6th of October the Books were finally removed, and, after being classified and arranged, were ready to be given out to Members on the 13th of October.

The Committee feel assured that the increased accommodation, and the better facilities for consulting books now afforded, will be satisfactory to the Members, while comfort and convenience, such as could not be secured in the former rooms, are provided in the new Reading-room, which will shortly be ready for occupation.

During the past year 253 volumes, 157 parts of works, and 26 pamphlets have been added to the Library, making a total of more than 8000 volumes, exclusive of pamphlets and parts of works. Of the periodicals at present received, 17 are weekly, of which 13 are bought and 4 presented; 5 are fortnightly, of which 4 are bought and 1 presented; 36 are monthly, of which 28 are bought and 8 presented; and 19 are quarterly, of which 15 are bought and 4 presented.

Exchanges of Transactions and Publications are made with 107 Societies and Public Departments, from which were received, during last year, 18 volumes and 133 parts. 151 volumes and 24 parts of works have been bought. 62 volumes (including 13 from the Commissioners of Patents) and 26 pamphlets have been presented to the Library, and the thanks of the Society are due to the donors. Acknowledgment of these will be found in the *Proceedings*, where a full list of all the additions for the year, and the names of the Societies and Public Departments with which publications are exchanged, have been printed. 228 volumes have been bound, and 12 are still in the hands of the binder.

Very considerable progress has this year been made in repairing the imperfections of the Library.

The Committee will be much pleased to have the co-operation of the Members in the selection of Books. A Book to receive the names of works recommended always lies on the table.

(Signed) JOHN ROBERTSON,
Hon. Librarian, Convener.

A vote of thanks to the Librarian and Treasurer was moved and carried unanimously.

The Society then proceeded to the election of Office-bearers.

It was moved by Dr. Fergus, the retiring President, that Dr. William Wallace, F.R.S.E., F.I.C., F.C.S., be elected President for the next three years. The motion was carried by acclamation, and Dr. Wallace took the chair as President.

It was moved by Dr. Andrew Buchanan, the retiring Vice-President, that Mr. Michael Connal, Chairman of the School Board of Glasgow, be elected a Vice-President of the Society for the next three years. The motion was passed unanimously.

The President moved the re-election of Mr. John Robertson, the Librarian, and Mr. John Mann, the Treasurer, respectively, which motion was carried by acclamation.

Mr. Michael Connal read the following Report of the Committee appointed on the 3rd of November to consider the whole question of the Secretaryship:—

REPORT OF COMMITTEE APPOINTED AT THE MEETING OF THE PHILOSOPHICAL SOCIETY ON WEDNESDAY, THE 3RD NOVEMBER, AS TO THE SECRETARYSHIP.

The Committee met on 9th November, 1880, at 16 Lynedoch Crescent. Present—Dr. Wallace, Dr. M'Vail, Mr. Muir, Mr. Scott, and Mr. Connal, from the Council; Dr. Hugh Thomson, Mr. Watson, Mr. James Thomson, and Mr. James Miller, from the Society—Mr. Nathaniel Dunlop being absent. The Committee, after mature deliberation, unanimously agreed to recommend that the Secretaryship should be offered to Professor M'Kendrick. The Committee make this recommendation, having reason to believe that the duties are so congenial to his tastes that, if the appointment be cordially offered, it will be accepted.

(Signed) MICHAEL CONNAL,
Convener.

It was moved by Mr. Michael Connal, and seconded by [illegible] Andrew Fergus, that Professor M'Kendrick be appointed Secretary. The motion was supported by Mr. Nathaniel Dunlop.

It was moved by Mr. William Dennison, and seconded by [illegible] Lindsay Miller, that Mr. John Mayer, F.C.S., be appointed Secretary. The Society then balloted for the Secretaryship, Mr. A. H. Maclean and Mr. James Nicol being appointed Scrutineers of the votes. The Scrutineers reported as follows:—Votes for Dr. M'Kendrick, 69; votes for Mr. Mayer, 43; majority in favour of Dr. M'Kendrick, 26. Dr. M'Kendrick was declared by the Chairman to be duly elected as the Secretary of the Society.

The President stated that the following four gentlemen retired by rotation at this time, viz.:—Mr. Alexander Scott, Mr. W. R. W.

Smith, Professor M'Kendrick, and Mr. J. Honeyman, I.A., F.R.I.B.A.; and that as he himself had been elected President, and Mr. Michael Connal a Vice-President, there would thus be six vacancies in the Council to be filled up.

It was moved by Mr. Alexander Scott and seconded by Mr. James Thomson, F.G.S., that the following gentlemen be elected Members of Council: — Mr. Nathaniel Dunlop, Mr. David Mackinlay, Mr. Robert Tatlock, F.R.S.E., F.C.S., Mr. James Brownlie, Dr. Neil Carmichael, and Mr. William Foulis.

The following gentlemen were also proposed and seconded, viz.:—Mr. James Thomson, F.G.S., and Mr. Mortimer Evans, C.E.

The Society then balloted for six Members of Council, Mr. James Paton, Mr. St. John Vincent Day, Mr. Lindsay Miller, and Mr. Easton being appointed Scrutineers.

The Scrutineers reported that the following had the greatest number of votes, viz.:—Mr. Tatlock, 96 votes; Mr. Foulis, 86 votes; Dr. Carmichael, 81 votes; Mr. N. Dunlop, 76 votes; Mr. Mackinlay, 69 votes; and Mr. Brownlie, 62 votes. These gentlemen were therefore declared by the Chairman to have been duly elected Members of the Council—Mr. Mackinlay and Mr. Brownlie to hold office for two years, in room of Dr. Wallace and Mr. Connal.

Dr. D. C. M'Vail moved and Dr. Andrew Buchanan seconded a motion that the thanks of the Society be given to Dr. ANDREW FERGUS for the able and zealous manner in which he had discharged the duties of President during the last three years. The motion was carried by acclamation.

Mr. James T. Bottomley, M.A., Demonstrator of Natural Philosophy, University of Glasgow, then gave the Society an interesting exposition and demonstration of a collection of Vacuum Tubes, illustrating the discoveries of Mr. William Crookes, F.R.S., in Molecular Physics. Mr. Bottomley received the cordial thanks of the Society.

(Signed) W. WALLACE.

Dr. ABSTRACT OF TREASURE

1880.—Oct. 30.

To Entry-money from 41 New Members, at 21s.,		£43 1 0	
,, Annual Dues from 1 Original Member for 1879-80, at 5s.,	£0 5 0		
,, Annual Dues from 578 Ordinary Members for 1879-80, at 21s.,	606 18 0		
,, Annual Dues from 38 New Members for 1879-80, at 21s.,	39 18 0		
		647 1 0	
,, Life Subscription from 3 New Members, .		31 10 0	
			£721 12
,, LEGACY—			
Trustees of the late Robert Napier, Esq., of Shandon, being a portion of the sum left for English and Scottish Institutions, ...			100 0
,, CHEMICAL SECTION—			
1 Associate for 1877-78, at 5s., . .		£0 5 0	
2 do. 1878-79, at 5s., . .		0 10 0	
26 do. 1879-80, at 5s., . .		6 10 0	
			7 5
,, Corporation of Glasgow, Interest on "Exhibition Fund" for year to Whitsunday, 1880—less Income Tax, .			48 19
,, *Proceedings*, &c., sold, ...			1 5
,, BATH STREET JOINT BUILDINGS—			
Society's half of First Instalment of Bond,		£900 0 0	
Temporary Advance from Joint Fund, .		210 0 0	
			1,110 0
,, Balance due Treasurer, ...			18 3
			£2,007 4 9

GLASGOW, *11th November, 1880.*—We, the Auditors appointed by the examined the same, of which the above is an Abstract, and found them Eighteen pounds three shillings and sixpence halfpenny.

Memo. by Treasurer.—The Amount of the Society's Funds invested in Bond, as above, £900=£1,175.—J. M.

STATEMENT—SESSION 1879-80. **Cr.**

1879.—Nov. 1.						
By Balance due Treasurer from last Session, . . .				£207	14	11½
1880.—Oct. 30.						
By Salary to Secretary, ...	£75	0	0			
,, Salary to Sub-Librarian, . . .	65	0	0			
,, Salary to Assistant in Library, . .	18	11	0			
,, Reporting, ...	4	4	0			
,, Allowance for Treasurer's Clerks, . .	15	0	0			
,, Gratuity to Officer of Corporation Galleries,	2	0	0			
,, Maclay, Murray, & Spens—Outlays connected with Incorporation of Society; no Professional Fees charged, . .	23	2	8			
				202	17	8
,, New Books, £114 8s. 2d.; Periodicals, £21 16s. 10d.; Foreign Periodicals, £3 18s. 6d., ...	140	3	6			
,, Binding, ...	58	17	0			
,, Lithographs and Woodcuts for *Proceedings*, &c.,	12	8	6			
,, Postage and delivery of Circulars, Letters, and Parcels, ...	37	13	6			
,, Stationery, ...	6	5	1			
				255	7	7
,, Rent of Rooms till Whitsunday, 1880, .	£100	0	0			
,, Do. Galleries, ...	30	0	0			
,, Fire Insurance for £5,400,. . .	13	10	6			
,, Furnishings and Repairs, . . .	3	5	3			
,, Gas, £7 8s. 5d.; Coal, £1 6s. 6½d.; Cleaning, 12s. 7½d., ...	9	7	7			
,, Postages, &c.—per Treasurer, £2 11s. 6d.; per Secretary, 5s., ...	2	16	6			
,, Sundries in Library, ...	2	2	5			
,, Interest on Advance by Bank, . .	1	7	7			
				162	9	10
,, Subscriptions to Societies—						
Ray Society, 1880, ...	£1	1	0			
Palæontographical Society, 1880, .	1	1	0			
				2	2	0
,, Chemical Section—						
Sum voted by Society to the "Graham" Medal and Lecture Fund, . .	£14	0	0			
Expenses per Treasurer of Section, .	2	12	9			
				16	12	9
,, Bath Street Joint Buildings—						
Society's half of Instalments to Tradesmen, . . .				1,160	0	0
				£2007	4	9½

ociety to examine the Treasurer's Accounts, for the year 1879-80, have orrect, the Balance due to the Treasurer at 30th October last being

he Bath Street Joint Buildings up to 31st October, 1880, is £2,075, less

(Signed) ARCH. HEWAT.
ALEX. S. BAIRD.

December 1, 1880.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the new Buildings, 207 Bath Street—Dr. William Wallace, President, in the Chair.

The Minutes of the last Meeting of the Society, having been printed in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairman.

The following were admitted as Members of the Society, viz.:—

Mr. Hugh M'Culloch, Mr. T. Graham Young, Mr. Georg Stuart, Mr. John M. Shaw, Mr. A. P. Henderson, Mr. Hug Paton, Mr. Walter E. Wingate, Mr. William Fife, Mr. Jam T. Bottomley, M.A., Mr. William Bottomley, jun., C.E., M Archibald Brownlie, Mr. David Maclure, Mr. George Smell Mr. James Brand, C.E., Mr. Wallace Fairweather, C.E., a Mr. D. A. Black.

All signed the Declaration and received the Diploma, with exception of Mr. T. Graham Young, Mr. A. P. Henderson, Mr. George Smellie, who were not present.

The following were proposed as Members of the Society, viz.

Mr. Francis Thornton Barrett, Librarian, the Mitchell Libr Recommended by Mr. John Robertson, Dr. Henry Muirhead, Mr. James Paton.

William Jack, LL.D., &c., Professor of Mathematics in University of Glasgow. Recommended by Sir William Thom Professor James Thomson, and Professor M'Kendrick.

John Barlow, M.D., Professor of Physiology in Anders College. Recommended by Sir William Thomson, Dr. He Muirhead, and Professor M'Kendrick.

Mr. John Lawson, Cranstonhill. Recommended by Mr. John Steven, Mr. William C. Coghill, and Mr. John Robertson.

Mr. David C. Hamilton, Engineer, Clyde Shipping Company, 2 Oswald Street. Recommended by Mr. John Steven, Mr. William C. Coghill, and Mr. John Robertson.

Mr. Alexander Nelson, 8 Prince's Square. Recommended by Mr. John Robertson, Mr. Archibald Robertson, and Professor M'Kendrick.

Mr. Adam Knox, Engineer, 47 Crownpoint Road, Mile End. Recommended by Mr. Wallace Fairweather, C.E., Mr. B. H. Romanes, and Mr. John Robertson.

Mr. John Stephen, Domira, Partick, Recommended by Dr. Wallace, Dr. Henry Muirhead, and Mr. Michael Connal.

Dr. Henry Muirhead read a paper on "Certain seeming relations between the three larger Planets crossing in front of the Sun's March, and the phenomena of Sun Spots and Terrestrial Magnetism." After some remarks by Mr. J. T. Bottomley, Dr. Muirhead received the thanks of the Society for his communication.

Mr. William Campbell, Assessor, read a paper on "Suggestions as to Amendment of various Franchises and Improvements in mode of Levying and Collecting Rates and Assessments in Scotland." After some discussion, in which the President, Mr. Nathaniel Dunlop, Mr. Michael Connal, Mr. Honeyman, Mr. Westlands, Mr. A. Scott, Mr. Mayer, and Mr. Edward, took part, Mr. Campbell received the thanks of the Society for his communication.

The following gentlemen, who were balloted for, were declared ly elected:—

Mr. William Campbell, Mr. James Fleming, Mr. John Harvie, r. Adam Elliot Black, Mr. William Pettigrew, Mr. Michael mons, Mr. M. Waddell, and Mr. N. B. Cameron.

(Signed) W. WALLACE.

December 15, 1880.

The Philosophical Society of Glasgow met this evening, at eight clock, in the new Buildings, 207 Bath Street—Dr. William Wallace, President, in the Chair.

The Minutes of the last Meeting of the Society, having been rinted in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairman.

The following were admitted as Members of the Society, viz.:—

Mr. William Campbell, Mr. James Fleming, Mr. John Harvie, Mr. Adam Elliot Black, Mr. William S. Pettigrew, Mr. R. H.

Pinkerton, Mr. Michael Simons, Mr. M. Waddell, and Mr. N. Cameron.

All signed the declaration and received the diploma, with [illegible] exception of Mr. A. E. Black, Mr. Michael Simons, and Mr. N. Cameron, who were not present.

The following were proposed as Members of the Society:—

Mr. Henry Davis, 16 Blythswood Square. Recommended by Mr. Walter Easton, Mr. George Watson, and Mr. John Mann.

Mr. James Blyth, M.A., F.R.S.E., Professor of Natural Philosophy in the Anderson's College. Recommended by Professor M'Kendrick, Professor Dittmar, and Mr. Robert Goodwin.

Mr. D. M'Laren Scott, Merchant, Carberry Villa, Tollcross Recommended by Dr. John Burns, Mr. John Mann, and Mr. William Hodge.

Mr. John M'Kissack, Architect, 175 St. Vincent Street. Recommended by Mr. David Thomson, I.A., F.R.I.B.A., Mr. A Lindsay Miller, and Mr. John Mann.

Mr. Allan Muir, Plumber and Brassfounder, 36 George Street Recommended by Mr. George Bell, F.R.I.B.A., Mr. Archibald Robertson, and Mr. Robert A. Bryden, F.R.I.B.A.

Mr. John Brown, Chemist, 11 Somerset Place. Recommended by Mr. Nathaniel Dunlop, Dr. James J. Dobbie, M.A., and Professor Ferguson.

Mr. W. G. Rowan, Architect, 175 St. Vincent Street. Recommended by Mr. David Thomson, I.A., F.R.I.B.A., Mr. A. Lindsay Miller, and Mr. John Mann.

Mr. Duncan Thomson, Agent, National Bank of Scotland, Anderston Branch, 15 Main Street, Glasgow. Recommended by Mr. William Sim, Mr. John Kirsop, and Mr. Archibald Robertson.

Mr. Andrew Jamieson, C.E., Principal of the Mechanics' Institution. Recommended by Sir William Thomson, Mr. J. T. Bottomley, and Professor M'Kendrick.

Dr. James Stirton, F.L.S., President of the Biological Sectio gave an Introductory Address "On Certain Phenomena happeni in the Lower Vegetable Organisms," in the conclusion of which referred to the evils arising in society from marriages betw people having an unhealthy constitutional taint. On the mot of the President, Dr. Stirton received a cordial vote of thanks for his address.

Professor M'Kendrick read a paper entitled "Some Observations on the Colouring Matter of the Jelly-fishes, *Chrysaora*, *Cyanea*, and *Aurelia*."

Mr. J. Bottomley made a short verbal communication "On the Electrostatic Behaviour of a Vacuum in Glass," and promised details at an early meeting of the Society.

Professor M'Kendrick made a short verbal communication to the effect that he had recently discovered that the Eye of the Frog is affected by light for a short time in a manner similar to the effect by light on the Selenium Cell in Professor Graham Bell's Photophone.

At 9.40 p.m., in accordance with the 13th Regulation of the Articles of Association, page 12, and as a matter of General Business, Mr. R. F. Muirhead, B.Sc., Delegate from the Society to the British Association, 1880, read a Report, which was ordered to be printed in the *Proceedings*, and for which he received a cordial vote of thanks.

The following were elected Honorary Members of the Society:—John Tyndall, LL.D., D.C.L., F.R.S., &c., Professor in the Royal Institution of London; Ernst Haeckel, Professor of Zoology in the University of Jena; and Andrew Buchanan, M.D., Emeritus Professor of the Institutes of Medicine in the University of Glasgow, late President of the Faculty of Physicians and Surgeons in Glasgow, &c.

The following gentlemen, who were balloted for as Ordinary Members, were declared duly elected:—Mr. Francis Thornton Barrett, Dr. William Jack, Dr. John Barlow, Mr. John Lawson, Mr. David C. Hamilton, Mr. Alexander Nelson, Mr. Adam Knox, and Mr. John Stephen.

(Signed) WILLIAM WALLACE.

January 5, 1881.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the New Buildings, 207 Bath Street—Dr. William Wallace, President, in the Chair.

The Minutes of the last Meeting of the Society, having been printed in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairman.

The Secretary read letters from Professor Tyndall and Dr. Andrew Buchanan, thanking the Society for their election as Honorary Members.*

The following were admitted as Members of the Society, viz.:—

Mr. Francis Thornton Barrett, Professor Jack, Professor Barlow, Mr. John Lawson, Mr. David C. Hamilton, Mr. Alexander Nelson, Mr. Adam Knox, and Mr. John Stephen.

All signed the Declaration and received the Diploma, with the exception of Professor Jack, Mr. John Lawson, and Mr. John Stephen, who were not present.

The following were proposed as Members of the Society:—

Mr. William Craig Ramsay, Writer, 134 St. Vincent Street.

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* "ROYAL INSTITUTION OF GREAT BRITAIN, *20th December*, 1880.—Dear Dr. M'Kendrick,—I take it as an act of great friendliness on the part of the Philosophical Society of Glasgow to choose me as an Honorary Member, and I beg of you to convey to the Society my warm thanks and acknowledgments for the distinction conferred on me.—Faithfully yours,

"(Signed) JOHN TYNDALL."

"186 BATH STREET, GLASGOW, *19th December*, 1880.—To the Secretary of the Philosophical Society of Glasgow.—My dear Dr. M'Kendrick, I beg to return my most sincere and grateful thanks for the altogether unexpected honour which the Philosophical Society of Glasgow have been pleased to confer upon me, in appointing me to be one of their Honorary Members. I would have been fully content to serve out my time in the ranks as an Ordinary Member, continuing to perform such little duties as might fall to my share in carrying on the work of the Society; although I cannot but feel that, after having seen the snows of eighty-two winters pass over my head, I am not quite the same man I was under the Presidency of my dear old friend Thomas Thomson, when I had for my friends and companions such men as Thomas Graham, Walter Crum, Andrew Liddel, and your late Secretary William Keddie, besides Andrew Anderson and R. D. Thomson. With these men I was borne along in the current, and did what I could not have done without their kind encouragement and assistance, and what, now that they are gone, I feel myself wholly unequal to perform.

"Please convey to the President and the other Office-bearers and Members of the Society my best thanks for the honour they have done me, and accept the same for yourself.—Ever, my dear Dr. M'Kendrick, yours most truly, (Signed) A. BUCHANAN."

Recommended by Mr. John Jex Long, Mr. John Urie, and Mr. Robert R. Tatlock.

Mr. William Gilfillan, Marble Cutter, 129 St. Vincent Street. Recommended by Mr. David Thomson, Mr. A. Lindsay Miller, and Mr. John Mann.

Mr. John Barclay, Calico Printer, 37 Monteith Row. Recommended by Mr. John Kirsop, Mr. Archibald Robertson, and Mr. John Mann.

Mr. Robertson, C.A., 28 Renfield Street. Recommended by Mr. John Kirsop, Mr. Archibald Robertson, and Mr. John Mann.

Mr. Alfred Schmidt, Manufacturing Chemist, 382 New City Road. Recommended by Mr. William R. W. Smith, Mr. John Mann, and Mr. Archibald Robertson.

Mr. Victor Zinkeisen, Merchant, 30 Cochran Street. Recommended by Mr. William R. W. Smith, Mr. John Mann, and Mr. Archibald Robertson.

Professor M'Kendrick read a paper on "The Physiological Action of Anæsthetics, being chiefly an account of an investigation of this subject by the Glasgow Committee of the British Medical Association, consisting of Professor M'Kendrick, Dr. Joseph Coats, Dr. William Ramsay, and Dr. David Newman." The paper was illustrated by diagrams and apparatus. In the discussion that followed, Dr. Newman described the results of that portion of the research relating to the influence of Anæsthetics on the Pulmonary Circulation. The thanks of the Society were awarded to the Committee.

Mr. F. J. Rowan read a paper on "A Method of foretelling the Quality of Wheat Harvests by the Wheat Blossoms," which contained an account of observations on this subject made by M. Bidard of Rouen. Mr. Rowan received the thanks of the Society.

Dr. Macphail exhibited and explained an Apparatus for estimating the amount of Fat in Bone, by means of a continuous stream of Ether.

The following gentlemen, who were balloted for as ordinary Members, were declared duly elected :—

Mr. Henry Davis, Professor James Blyth, Mr. D. M'Laren Scott, Mr. John M'Kissack, Mr. Allan Muir, Mr. John Brown, Mr. W. J. Rowan, Mr. Duncan Thomson, and Mr. Andrew Jamieson.

(Signed) WILLIAM WALLACE.

January 19, 1881.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the New Buildings, 207 Bath Street—Dr. William Wallace, President, in the Chair.

The Minutes of the last Meeting of the Society having been printed in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairman.

The following were admitted as Members of the Society, viz.:

Mr. Henry Davis, Professor Blyth, M.A., Mr. D. M'Laren Scott, Mr. John M'Kissack, Mr. Allan Muir, Mr. John Brown, Mr. W. G. Rowan, Mr. Duncan Thomson, and Mr. Andrew Jamieson, C.E.

All signed the Declaration and received the Diploma, with the exception of Mr. Allan Muir, Mr. W. G. Rowan, and Mr. Duncan Thomson, who were not present.

The following were proposed as Members of the Society:—

Dr. Ramsay, Lochwinnoch. Recommended by Dr. Fergus, Dr. M'Kendrick, and Mr. John Jex Long.

Mr. Charles H. Barclay, 28 Westbourne Gardens. Recommended by Dr. Henry Muirhead, Dr. M'Kendrick, and Mr. John Mann.

Mr. D. M. Macleod, Merchant, 8 Victoria Terrace, Downhill. Recommended by Mr. W. E. Wingate, Mr. John Mann, and Dr. M'Kendrick.

Mr. Laurence Hill Wight, Lecturer on Mathematics and Navigation and Nautical Astronomy, Mechanics' Institute. Recommended by Mr. Robert R. Tatlock, Professor Ferguson, and Dr. M'Kendrick.

Mr. John D. Campbell made a communication "On the Place of Phonetics in Primary Education," for which he received the thanks of the Society.

Mr. Andrew Jamieson, C.E., read a paper on "The History of Selenium and the Action of the Selenium Cell in Mr. Graham Bell's Photophone." The paper was illustrated by diagrams and experiments, and, in particular, Mr. Jamieson showed a new form of Photophone invented by himself, the efficiency of which was satisfactorily tested by several members of the Society. After some discussion, in which Sir William Thomson, Mr. Miller, Professor Blyth, Mr. Mayer, and Mr. Muir took part, Mr. Jamieson received the thanks of the Society.

Dr. David Newman exhibited and explained an Apparatus for Estimating the Amount of Hæmoglobin and Biliary Pigments in Urine by means of the Spectroscope.

Professor M'Kendrick showed a Chronograph of simple construction, sent to him by Professor Kronecker, Physiological Laboratory, University of Berlin, and invented by Dr. Grunmach.

The following gentlemen, who were balloted for as Ordinary Members, were declared duly elected:—

Mr. William Craig Ramsay, Mr. William Gilfillan, Mr. John Barclay, Mr. Robert Paterson, Mr. Alfred Schmidt, and Mr. Victor Zinkeisen.

(Signed) WILLIAM WALLACE.

February 2, 1881.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the New Buildings, 207 Bath Street—Dr. William Wallace, President, in the Chair.

The Minutes of the last Meeting of the Society having been printed in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairmam.

The Secretary read a letter from Professor Hæckel, thanking the Society for his election as an Honorary Member.*

The following were admitted as Members of the Society, viz.:—

Mr. William Craig Ramsay, Mr. William Gilfillan, Mr. John Barclay, Mr. Robert Paterson, Mr. Alfred Schmidt, and Mr. Victor Zinkeisen.

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* "JENA, 31*st December*, 1880.—To the Philosophical Society of Glasgow.—The Philosophical Society has done me the high honour of appointing me an Honorary Member. Whilst I return them my most heartfelt thanks for this honourable distinction, I recognise in it, not so much a reward for scientific services already rendered, as an encouragement to continue the exertions in the paths of biological research to which I have already devoted twenty years. I know that in this I shall have the sympathy of the Members of the Philosophical Society of Glasgow; and with renewed assurance of my sincere thanks, I beg that they may continue to have me in their good esteem. (Signed) ERNST HÆCKEL."

All signed the Declaration and received the Diploma, with the exception of Mr. Robert Paterson, Mr. Alfred Schmidt, and Mr. Victor Zinkeisen, who were not present. Mr. Adam Knox, Mr. Allan Muir, and Mr. Duncan Thomson also signed the Declaration and received their Diplomas.

The following were proposed as Members of the Society:—

Mr. William Milne, Mathematical and Science Master, High School. Recommended by Mr. Thomas Muir, M.A., F.R.S.E., Dr. Muirhead, and Mr. John Robertson.

Mr. William Reid, Mathematical and Science Master, High School. Recommended by Mr. Thomas Muir, M.A., F.R.S.E., Dr. Muirhead, and Mr. John Robertson.

Mr. William Buchanan, Registrar, 10 Carrington Street, West. Recommended by Mr. Alexander Scott, Dr. Fergus, and Mr. John Robertson.

Dr. Maddiver, Rothesay. Proposed by Mr. John Kirsop, Dr. Fergus, and Dr. M'Kendrick.

Mr. Charles J. Blair, 6 Alfred Terrace, Hillhead. Proposed by Mr. Thomas D. Cree, Charles Wilson, and Archibald Robertson.

Sir William Thomson stated that since the last meeting of the Society he had had an opportunity of re-examining the effects produced by the form of Photophone invented by Mr. Jamieson, and that he was satisfied that articulate language could be transmitted with remarkable fidelity and distinctness.

Mr. Archibald Hewat, F.F.A., read a paper on "Mortality Tables," for which he received the thanks of the Society.

Mr. John Aitken, F.R.S.E., Darroch, Falkirk, read a paper "On the Formation of Mists, Fogs, and the Condensation of Watery Vapour,"* in which he illustrated by various experiments his view that nuclei, in the form of fine, impalpable dust-particles, form centres around which watery vapour condenses. After some remarks by the President, Sir William Thomson, Professor James Thomson, Mr. James Robertson, Mr. Goodwin, Mr. Evans, and Mr. W. R. W. Smith, Mr. Aitken received a cordial vote of thanks for his paper, which he had kindly communicated to the Society at the request of the Council.

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* This paper has appeared in the *Proceedings* of the Royal Society of Edinburgh for the present Session.

The following gentlemen, who were ballotted for as Ordinary Members, were declared duly elected:—

Dr. Ramsay, Mr. Charles H. Barclay. Mr. D. M. Macleod, and Mr. Laurence Hill Wight.

(Signed) WILLIAM WALLACE.

February 16, 1881.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the New Buildings, 207 Bath Street—Dr. William Wallace, President, in the Chair.

The Minutes of the last Meeting of the Society having been printed in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairman.

The following were admitted as Members of the Society, viz.:—

Dr. Ramsay, Mr. Charles H. Barclay, Mr. D. M. Macleod, and Mr. L. H. Wight.

Sir William Thomson showed a number of interesting experiments with Gyrostats, and explained their dynamical principles, and their application to the illustration of the Precession of the Equinoxes, the Flight of a Conical Bullet, and Faraday's Law of the Rotation of Polarized Light in the Magnetic Field. A vote of thanks was cordially given to Sir William Thomson.

Professor Blyth read a paper "On a Wire Telephone or Electric Sonometer," and illustrated its action by experiments. He also showed the action of various kinds of Telephonic Transmitters and Receivers, such as the Wire-drum Receiver, the Grindstone Receiver, and a Transmitter containing copper plates and red amorphous phosphorous, which he had recently invented, and in which a feeble electrical current was produced. After some remarks by Sir William Thomson, Mr. Blyth received the thanks of the Society.

Sir William Thomson represented to the Society that it was highly desirable immediately to petition the Government regarding the Law of Patents, in the same terms as those of the petition presented last year, and he moved that the Committee of last year be reappointed. This motion, seconded by Mr. Mayer, was unanimously agreed to. Dr. M'Kendrick moved, and Mr. James Thomson seconded, that the Committee be entrusted with powers to petition the Government in the terms of the petition of last year, and to watch the progress of the matter. This was also unanimously agreed to.

The following gentlemen, who were ballotted for as Ordinary Members, were declared duly elected:—

Mr. William Milne, Mr. William Reid, Mr. William Buchanan, Dr. Maddiver, and Mr. Charles J. Blair.

(Signed) MICHAEL CONNAL for DR. WALLACE.

March 2, 1881.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the New Buildings, 207 Bath Street—Mr. Michael Connal, Vice-President, in the Chair.

The Minutes of the last Meeting of the Society, having been printed in the notice calling this Meeting, were held as read, [illegible] were confirmed and signed by the Chairman, on behalf of [illegible] Wallace, who presided at last Meeting.

The following were admitted as Members of the Society, viz.:—

Mr. William Milne, Mr. William Reid, Mr. William Buchanan, Dr. Maddiver, and Mr. Charles J. Blair.

All signed the Declaration and received the Diploma, with the exception of Dr. Maddiver, who was not present. Mr. Michael Simons, Dr. Ramsay, and Mr. Laurence Hill Wight, also signed the Declaration, and received their Diplomas.

The following were proposed as Members of the Society:—

Mr. John W. Spence, Ardlin, Helensburgh. Recommended by Dr. Wallace, Mr. Napier Smith, and Mr. John Clark.

Mr. George G. Chisholm, Litterateur, Messrs. Blackie & Son, 17 Stanhope Street. Recommended by Dr. Glaister, Dr. M'Kendrick, and Mr. Michael Connal.

Mr. Gavin Miller Buchanan, Registrar of Births, &c., 121 Kennedy Street, Glasgow. Recommended by Dr. Glaister, Mr. Alexander Scott, and Dr. M'Kendrick.

Mr. T. Lindsay Galloway, Civil Engineer, 28 St. Enoch Square. Recommended by Sir William Thomson, Mr. J. T. Bottomley, and Mr. William Ker.

Mr. T. H. Jones, Principal of the Greenock Articulation School, lately from the School of Vocal Physiology, Boston University, U.S.A., read a paper on "Visible Speech and its Application to the Teaching of the Deaf." He illustrated the system with the aid of four girls, who showed remarkable proficiency in the use of the physiological alphabet of Mr. Melville Bell, and in lip language. They articulated distinctly, and showed that by this method they had acquired a knowledge of reading, writing, and arithmetic. After some remarks by Professor Ramsay, Dr. M'Kendrick, Dr. Barr, and Mr. David Edward, Mr. Jones received the cordial thanks of the Society for his interesting communication.

(Signed) WILLIAM WALLACE.

March 16, 1881.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the New Buildings, 207 Bath Street—Dr. Wallace, President, in the Chair.

The Minutes of the last Meeting of the Society, having been printed in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairman.

The following were proposed as Members of the Society:—

Bailie John Mowat, 13 Montgomerie Crescent, Kelvinside. Recommended by Dr. Wallace, Mr. Michael Connal, and Bailie Morrison.

Mr. Robert Binnie, Merchant, Ashbourn, Gourock. Recommended by Mr. J. L. Mitchell, Mr. Michael Connal, and Mr. Robert Balloch.

Mr. William Wilson, Merchant, Virginia Buildings, Glasgow.

Recommended by Mr. J. L. Mitchell, Mr. Michael Connal, and Mr. Robert Balloch.

Mr. Joseph Jeffries, District Manager, National Telephone Company (Limited), 13 Royal Exchange Square. Recommended by Mr. David Graham, Jun., Mr. John Robertson, and Mr. Archibald Robertson.

Mr. Maxwell Hannay, 104 West George Street. Recommended by Mr. James L. Mitchell, Mr. Michael Connal, and Dr. M'Kendrick.

Mr. Gilbert Beith, 19 West Nile Street. Recommended by Mr. James L. Mitchell, Mr. Michael Connal, and Dr. M'Kendrick.

Mr. Joseph D. Swan, of Newcastle-upon-Tyne, addressed the Society on his method of Electric Lighting by an Incandescent Lamp. He described the construction of his lamps, 20 of which were exhibited in full operation in the room. He showed how the number might be regulated, and how quickly one lamp might be substituted for another. He also showed a lamp specially designed for use in mines. The address was illustrated by brilliant experiments. In the discussion, remarks were made by the President, Sir William Thomson, Mr. T. R. Ogilvie, F.C.S., Mr. Jamieson, C.E., Mr. Mortimer Evans, C.E., Professor James Thomson, Mr. W. P. Buchan, Professor Blyth, Mr. Mactear, Mr. Mayer, Mr. N. Dunlop, and Dr. M'Kendrick. A cordial vote of thanks was given to Mr. Swan. A vote of thanks was also awarded to Messrs. D. & G. Graham, Telegraph Engineers, Sauchiehall Street, for supplying the electric current, and for making the necessary arrangements for transmitting it from their premises in Sauchiehall Street to the rooms of the Society. The machine employed was a B Gramme, worked by a 4½ H.-P. steam-engine.

The following gentlemen, who were ballotted for as Ordinary Members, were declared duly elected:—

Mr. John W. Spence, Mr. George G. Chisholm, Mr. Gavin Miller Buchanan, and Mr. T. Lindsay Galloway.

(Signed) WILLIAM WALLACE.

March 30, 1881.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the New Buildings, 207 Bath Street—Dr. Wallace, President, in the Chair.

The Minutes of the last Meeting of the Society, having been printed in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairman.

The following were admitted as Members of the Society, viz.:—

Mr. John W. Spence, Mr. George G. Chisholm, Mr. Gavin Miller Buchanan, and Mr. T. Lindsay Galloway.

The following was proposed as a Member of the Society:—

Mr. Archibald Watson, Plumber, 29 Elmbank Crescent. Recommended by Mr. W. Forrest Salmon, Mr. Richard Nairn, and Mr. Allan Muir.

Dr. Eben. Duncan read a paper entitled—"Some Observations on our Present Methods of Disposal of Human Excreta, and their Relation to the Spread of Epidemic Disease." After some discussion, a cordial vote of thanks was given to Dr. Duncan.

Dr. M'Kendrick showed an arrangement for Demonstrating the Rhythm of the Pulse by sound.

Mr. Alexander Scott showed and described a large Index Barometer, invented by himself, by which the movements of the barometrical column were much amplified.

Mr. Mayer moved, and Mr. Alexander Scott seconded, that the President and Secretary be authorised to sign, on behalf of the Society, a Petition to Parliament in support of the Patent Law Amendment Bill, and to affix the seal of the Society thereto.*

The following gentlemen, who were ballotted for as Ordinary Members, were declared duly elected:—

Bailie John Mowat, Mr. Robert Binnie, Mr. William Wilson, Mr. Joseph Jeffries, Mr. Maxwell Hannay, and Mr. Gilbert Beith.

(Signed) WILLIAM WALLACE.

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* A Petition, similar to that printed on page 425 of the *Proceedings* for 1879-80, was drawn up, signed, and forwarded to Mr. George Anderson, M.P., who presented it to the House of Commons.

April 13, 1881.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the New Buildings, 207 Bath Street—Dr. Wallace, President, in the Chair.

The Minutes of the last Meeting of the Society, having been printed in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairman.

The following were admitted as Members of the Society, viz.:—

Bailie John Mowat, Mr. Robert Binnie, Mr. William Wilson, Mr. Joseph Jeffries, Mr. Maxwell Hannay, and Mr. Gilbert Beith.

Mr. Wilson and Mr Hannay signed the declaration, and received their diplomas.

Mr. Napier Smith read a paper on the "Origin and Formation of Colour," which he illustrated by experiments, and for which he received the thanks of the Society.

Mr. James Hannay showed an experiment proving that ice cannot be superheated *in vacuo*, as stated by Dr. Carnelly. After some remarks by Sir William Thomson, Professor James Thomson, and Mr. Coleman, Mr. Hannay received the thanks of the Society.*

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* In a letter to the Secretary, Mr. Hannay thus describes the experiment:—

"Private Laboratory, Sword Street, Glasgow, 16*th April*, 1881.—Prof. John G. M'Kendrick, M.D.—Dear Sir,—The experiment I showed was this:—A piece of clear transparent ice was frozen round a thermometer, and then placed in a flask full of mercury below 0°. The flask was fitted with a stopper through which passed a long tube and the thermometer. By inverting, the mercury ran out, leaving a Torricellian vaccuum in the flask containing the ice. The bulb of the flask was placed in a freezing mixture, while the ice was in the neck protruding from the mixture. The glass round the ice could be heated to the softening point without the ice showing the slightest signs of melting. Increase of heat only increased the *rate* of volatilization of the ice, as increase of heat only increases the rate of boiling of water without raising its temperature over 100°. By the vacuum the *boiling* point of the water is lowered below its *freezing* point, so the ice can never melt but only *volatilize* directly from the solid state—the two operations, fusion and boiling, being performed as one. I hope I have succeeded in making the matter clear.—I am, faithfully yours,

"(Signed) J. B. Hannay."

Mr. Archibald Watson was duly elected by ballot as an Ordinary Member of the Society.

(Signed) WILLIAM WALLACE.

April 27, 1881.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the New Buildings, 207 Bath Street—Dr. Henry Muirhead, Vice-President, in the Chair.

The Minutes of the last Meeting of the Society, having been printed in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairman.

Mr. Archibald Watson was admitted a Member of the Society, signed the declaration, and received his diploma.

Dr. James Stirton, F.L.S., &c., read a paper on the "Vegetable Parasites on the Tea Plant, more especially that of Assam," for which he received the thanks of the Society.

Mr. James Thomson, F.G.S., read a paper on "Corals—Alveolites, Amplexus, and Zaphrentis," for which he received the thanks of the Society.

Dr. M'Vail made some observations in approbation of Mr. Thomson's work, and suggested that the Society should consider the expense Mr. Thomson bears in connection with the illustration of his several papers read before the Society, and the propriety of his being relieved of such expense by the Society.

(Signed) WILLIAM WALLACE.

The Society held another Meeting on 7th May, 1881, when Mr. John P. Craig read a paper on "The Cleansing of Cities and the Utilization of Sewage," and when Reports were given in from the various Sections. The Minute of this Meeting, if approved, will appear in next volume of the *Proceedings.*

REPORT OF THE ARCHITECTURAL SECTION OF THE GLASGOW PHILOSOPHICAL SOCIETY FOR SESSION 1880-81.

During the Session seven Meetings of the Section have been held, the papers read being as follows:—

December 8, 1880.—David Thomson, Esq., F.R.I.B.A., President of the Section, delivered his Opening Address—“The Architecture of Glasgow.”

December 22, 1880.—Mr. Robert Turnbull read a paper entitled “Notes on Building Construction.”

January 26, 1881.—Mr. Edward Howell read a paper on “The Artistic Tendency of House Furnishing, and how best to sustain and promote it.”

February 9, 1881.—Mr. Robert Scott read a paper on “Measurers, their position and practice.”

February 23, 1881.—The discussion on Mr. Scott's paper continued.

March 9, 1881.—Mr. John Honeyman, F.R.I.B.A., read a paper on “Legislation affecting Dwelling-Houses.”

March 23, 1881.—Mr. John Dansken read a paper on “Building Construction, a protection from Fire.”

The thanks of the Section are due to all these gentlemen.

During the Session 8 associates were admitted to Section.

On March 23, after the discussions on Mr. John Dansken's paper, the Annual Meeting of the Section was held, for the purpose of receiving Reports of last Session and electing Office-bearers for the Session.

The following gentlemen were elected to office:—

President.—James Sellars, Esq., Architect.

Vice-Presidents.—Messrs. James Thomson, Architect, and George J. Combe, Esq., Engineer.

Treasurer.—James Howell, Esq., 146 Buchanan Street.

Secretary.—A. Lindsay Miller, 121 West Regent Street.

Members of Council.—Mr. John Honeyman, Mr. Campbell Douglas, Mr. Robert Scott, Mr. David Thomson, Mr. Robert Turnbull, Mr. John Cowan, Mr. William Landless, Mr. Alexander Muir, Mr. John Dansken, Mr. T. L. Watson.

(Signed) A. LINDSAY MILLER, *Secretary.*

REPORT OF THE BIOLOGICAL SECTION FOR SESSION 1880-81.

The Office-bearers[‡] of this Section are the same as last year. During the Session, papers were read by the President, Dr. Stirton, and by Mr. James Thomson, F.G.S.

(Signed) D. C. M'VAIL, *Secretary.*

REPORT OF THE CHEMICAL SECTION OF THE PHILOSOPHICAL SOCIETY FOR SESSION 1880-81.

During Session 1880-81 this Section held nine General Meetings, at which the average attendance was 29. Twenty-two gentlemen were admitted associates of the Section in the course of the Session.

The following is a list of the papers contributed to the Section:—

November 8, 1880.—(1) President's Opening Address. (2) "On the Desilverization of Lead by the Zinc Process," by Mr. J. E. Stoddart.

November 22, 1880.—"On the Action of Concentrated Sulphuric Acid on Lead, at Ordinary Temperatures," by Mr. Jas. Napier, Jun. An important discussion—in which Mr. Mactear, Mr. C. Hope, Mr. W. G. Chrystal, Dr. Wallace, Mr. Stoddart, and others took part—followed the reading of this paper.

December, 6, 1880.—* "On the Chemistry of Sewage Precipitation," by Dr. Wallace.

December, 20, 1880.—* "Geber," by Professor Ferguson.[§]

[‡] List of Office-bearers will be found on p. 272.

[§] The publication of this paper has been deferred by the author till next Session.

January 24, 1881.—Adjourned discussion on Dr. Wallace's paper "On the Chemistry of Sewage Precipitation."

February 7, 1881.—(1) "On the Detection of Nitrates and Sulphocyanates in a Mixture containing Ferro- and Ferricyanides," by Mr. J. Smaigram. (2) "On the Detection and Estimation of Ferrocyanides, Sulphocyanides, and Cyanides in presence of one another," by Mr. C. Hope. (3) "On the Estimation of Manganese," by Mr. Macnear and Mr. C. Hope.

February 21, 1881.—(1) "On the Removal of Aqueous Vapour from Air," by Mr. Coleman. (2) "On some Researches connected with the Manufacture of Artificial Manures," by Mr. H. B. Yardley. (3) "On the Formation of Sodium Hydrate from the Sulphate," by Mr. Ed. J. Bevan, and Mr. C. F. Cross.

March 7, 1881.—(1)* "On the Artificial Production of Indigo," by Mr. A. G. Perkin. (2) "On the State of Carbon in Iron and Steel," by Dr. Sydney Marsden. (3) "On a New Compound of Hydrogenium," by Lt.-Col. W. A. Ross.

April 4, 1881.—(1)* "On Soap Analysis," by Mr. C. Hope. (2) "On the Occurrence and Composition of Euxenite and other rare Minerals," by Dr. Dobbie, Mr. R. Thomson, and Mr. E. B. Clark. (3) "On the Conversion of Dolomitic Limestone into Serpentine," by Dr. Dobbie.

The papers—four in number—marked with an asterisk, were recommended to the Council of the Philosophical Society for publication.

A full report of the discussions, taken by Mr. Cunningham, Shorthand Reporter to the Section, is preserved amongst the papers of the Section.

(Signed) JAMES JOHNSTON DOBBIE,

Secretary of Section.

REPORT OF THE SANITARY AND SOCIAL ECONOMY SECTION FOR SESSION 1880-81.

No meeting of the Council of the Sanitary Section has been held since 17th November last, on which date the office-bearers of the

Section were elected, and the programme for the Session agreed upon.[*] Of the papers recommended by the Sanitary Section to the Council of the Society as suitable to be read before the General Meetings of the Philosophical Society, all were read except the paper by Dr. Neil Carmichael "On an Experimental Investigation into the Trap and Water-Closet System, and the Relation of the same to Sewage Products, Gaseous and other." Dr. Carmichael was not able to complete his investigations, so that this paper is carried forward to next Session.

(Signed) EBEN. DUNCAN,
Secretary to the Sanitary Section.

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[*] List of Office-bearers will be found on p. 273.

OFFICE-BEARERS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW.

SESSION 1880-81.

Dr. William Wallace, F.R.S.E., F.I.C., F.C.S., *President.*

Dr. Henry Muirhead. Mr. Thomas Muir, M.A., F.R.S.E. Mr. Michael Connal.	*Vice-Presidents.*
Dr. Allen Thomson, LL.D., F.R.S. Professor Grant, M.A., LL.D., F.R.S. Professor Sir Wm. Thomson, LL.D., D.C.L., F.R.S., Dr. Andrew Fergus, M.R.C.S.Eng.	*Honorary Vice-Presidents.*

Mr. John Robertson, *Librarian.*

Mr. John Mann, C.A., *Treasurer.*

Professor John Gray M'Kendrick, M.D., F.R.S.E., F.R.C.P.E., *Secretary.*

Mr. David Thomson, I.A., F.R.I.B.A., *Architectural Section,* Dr. James Stirton, F.L.S., *Biological Section,* Mr. James Mactear, F.C.S., *Chemical Section,* Dr. James B. Russell, B.A., *Sanitary and Social Economy Section.*	*Presidents of Sections.*

Other Members of Council.

Mr. Archibald Robertson.	Mr. David Mackinlay.
Mr. J. J. Coleman, F.I.C., F.C.S.	Mr. James Brownlie.
Mr. D. C. M'Vail, M.B.	Mr. R. Tatlock, F.R.S.E., F.C.S.
Mr. John Kirsop.	Mr. William Foulis.
Mr. John Jex Long.	Dr. Neil Carmichael.
Dr. Eben. Watson, M.A.	Mr. Nathaniel Dunlop.

COMMITTEES APPOINTED BY THE COUNCIL.

COMMITTEE ON FINANCE.

Dr. Wallace, *President.*

Mr. David Mackinlay.	Mr. Nathaniel Dunlop.
Mr. J. J. Coleman.	Mr. Michael Connal.
Mr. John Kirsop.	Mr. John Jex Long.

Mr. John Mann, *Treasurer, Convener.*

Mr. Archibald Robertson, *Sub-Convener.*

COMMITTEE ON PAPERS.

DR. WALLACE, *President.*
DR. HENRY MUIRHEAD, } *Vice-Presidents.*
MR. THOMAS MUIR, }

MR. DAVID THOMSON.
DR. JAMES STIRTON.
MR. JAMES MACTEAR.
DR. J. B. RUSSELL.
DR. NEIL CARMICHAEL.
MR. WILLIAM FOULIS.
DR. D. C. M'VAIL.
MR. R. TATLOCK.
MR. MICHAEL CONNAL.
MR. JOHN JEX LONG.
DR. EBEN. WATSON.

PROFESSOR M'KENDRICK, *Convener.*

COMMITTEE ON THE LIBRARY.

DR. WALLACE, *President.*
DR. HENRY MUIRHEAD, }
MR. THOMAS MUIR, } *Vice-Presidents.*
MR. MICHAEL CONNAL, }

DR. JAMES STIRTON.
MR. JAMES MACTEAR.
DR. J. B. RUSSELL.
MR. JAMES BROWNLIE.
MR. J. J. COLEMAN.
DR. D. C. M'VAIL.
MR. JOHN KIRSOP.

MR. JOHN ROBERTSON, *Librarian, Convener.*

COMMITTEE ON BUILDING AND ACCOMMODATION.

Acting jointly with the Council of the Institute of Engineers and Shipbuilders in Scotland.

DR. WALLACE, *President.*
DR. HENRY MUIRHEAD, } *Vice-Presidents.*
MR. THOMAS MUIR, }

MR. DAVID THOMSON.
DR. J. B. RUSSELL.
MR. ARCHIBALD ROBERTSON.
MR. J. J. COLEMAN.
MR. JOHN KIRSOP.
MR. JOHN JEX LONG.
MR. JOHN ROBERTSON, *Librarian.*
MR. JOHN MANN, *Treasurer.*

HOUSE COMMITTEE FROM BOTH SOCIETIES.

Institution of Engineers and Shipbuilders.	*Philosophical Society.*
MR. MANSEL.	DR. WALLACE.
MR. JAMIESON.	MR. ARCHIBALD ROBERTSON.
MR. GALE.	MR. JOHN KIRSOP.

OFFICE-BEARERS OF SECTIONS.

ARCHITECTURAL SECTION.

Mr. David Thomson, I.A., F.R.I.B.A., *President.*

Mr. James Sellars, I.A.,
Mr. Andrew Wells, } *Vice-Presidents.*

Mr. James Howatt, *Hon. Treasurer.*

Mr. A. Lindsay Miller, *Hon. Secretary,*
121 West Regent Street.

Other Members of Council.

Mr. J. Honeyman, I.A., F.R.I.B.A.
Mr. John Cowan.
Mr. James Thomson, I.A., 81 St. Vincent Street.
Mr. L. Cowan, I.A.
Mr. George J. Combe.
Mr. Stephen Adam.
Mr. William Landless.
Mr. Campbell Douglas, I.A.

BIOLOGICAL SECTION.

Dr. James Stirton, F.L.S., *President.*

Mr. James Thomson, F.G.S.,
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Association Française pour l'Avancement des Sciences. 8me. Session. Montpellier, 1879.

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70*Brown, John, Chemist, 11 Somerset place. 1881
Brown, Nicol, 21 Hope street. 1869
Brown, Richard, Strone Colliery Co., 49 W. George street. 1855
Brown, Robert Langton, 92 St. Vincent street. 1875
Brownlie, Archibald, Writer, 225 W. George street. 1880
75 Brownlee, Jas., 23 Burnbank gardens. 1860
Brownlie, Jas., Victoria Saw Mills. 1877
Brownlie, John, 2 Oakley terrace. 1874
Bruce, John Inglis, Helen street, Govan. 1869
Bruce, John L., I.A., 103 West Regent st. 1873
80 Bryce, David, 129 Buchanan street. 1872
Bryden, Robt. A., F.R.I.B.A., 15 Dalhousie street. 1870
Buchan, William P., 21 Renfrew st. 1875
Buchanan, Alex. M., M.A., M.D., Professor of Anatomy in Anderson's College, 201 St. George's rd. 1876

Buchanan, Gavin Miller, Registrar of Births, &c., 121 Kennedy st. 1881
85 Buchanan, George, A.M., M.D., Professor of Clinical Surgery in the University of Glasgow, 193 Bath street. 1875
Buchanan, Geo. S.. 95 Candleriggs. 1845
Buchanan, William L., 212 St. Vincent street. 1873
Buchanan, William, Registrar, 10 Carrington street, west. 1881
Burnet, John, 167 St. Vincent st., 1850
90 Burns, J., M.D., 15 Fitzroy place, Sauchiehall street. 1864
Burns, J. Cleland, Ferntower, Crieff. 1874

Cameron, Charles, M.D., LL.D., M.P., 104 Union street. 1870
Cameron, H. C., M.D., 27 Elmbank crescent. 1873
Cameron, N. B., Draper, Cambuslang. 1880
95 Cameron, R., 1 North Claremont st. 1873
Campbell, J. A., LL.D., M.P., 29 Ingram street. 1848
Campbell, John D., 5 Derby terrace, Sandyford. 1858
Campbell, William, Assessor, 24 Ingram street. 1880
Carlile, Thomas, 23 West Nile st. 1851
100 Carlton, Charles, 141 St. Vincent st. 1870
Carmichael, Neil, M.D., C.M., 29 S. Cumberland street. 1873
Carmichael, Thomas, 9 Windsor st., New City road. 1879
Carrick, John, City Architect, 74 Hutcheson street. 1846
Cassels, Robert, 168 St. Vincent st. 1858
105 Cassells, J. P., M.D., 2 Newton ter. 1874
Cherrie, James M., Clutha cottage, Tollcross. 1876
Chisholm, George G., Littérateur, 17 Stanhope street. 1881
Christie, James, A.M., M.D., F.F.P.S.G., 2 Great Kelvin terrace, Bank street, Hillhead. 1876
Christie, John, Turkey-red Works, Alexandria, Dumbartonshire. 1868
110 Chrystal, W. J., Shawfield Works, Rutherglen. 1880
Church, James, 88 Renfield street. 1867
Church, Wm., Jun., 67 St. Vincent street. 1855
Clapperton, John, 5 Sandyford pl. 1874
*Clark, G. W., Dumbreck house, 1877
115 Clark, Henry E., L.R.C.S. Eng., 9 Elmbank street. 1876
Clark, John, Ph.D., F.I.C., F.C.S., 138 Bath street. 1870
Clark, John, 9 Wilton crescent. 1872
*Clark, William, Mile-end. 1876
Clavering, Thos., 21 St. Vincent pl. 1856
120 Cleland, A. B. Dick, Merlewood, Lenzie. 1871
Clinkskill, James, 1 Holland place. 1868
Clouston, Peter, 1 Park terrace. 1861
Coats, Joseph, M.D., 7 Elmbank crescent. 1873
*Cochran, Robert, 7 Crown circus, Dowanhill. 1877
125 Coghill, Wm. C., 263 Argyle street. 1873
Coleman, J. J., F.C.S., 45 West Nile street. 1869
Collins, Wm., 3 Park terrace, East. 1869
Collins, Wm., Jun., 139 Stirling rd. 1879
Colquhoun, Jas., 158 St. Vincent street. 1876
130 Combe, George Jones, 34 Dundas st. 1877
Combe, William, Regent terrace, Stirling road. 1877
Connal, Michael, Virginia buildings, *Vice-President*. 1848
Connell, James, 182 Crookston st. 1870
Connell, Wm., 38 St. Enoch square. 1870
135 Copeland, Jas., 1 Thornville terrace, Hillhead. 1869
Copland, Wm. R., M. Inst. C.E., 146 West Regent street. 1876
Coubrough, A. Sykes, Blanefield, Strathblane. 1869
Couper, James, Craigforth House, Stirling. 1862
Couper, James, 37 Lansdowne cres. 1878
140 Couper, Wm., 9 Huntly gardens, Hillhead. 1873
Cowan, J. B., M.D., Woodend house, Helensburgh, 1867
Cowan, John, 12 Ure place. 1870
Cowan, M'Taggart, C.E., 27 Ashton terrace, Hillhead. 1876
Cranston, George, Jun., 91 Sauchiehall street. 1880
145 Crawford, David, Jun., Fereneze Print Works, Barrhead. 1873
Crawford, W. B., 104 West Regent street. 1872
Crawford, William C., M.A., Hobart house, Eskbank, near Edinburgh. 1869
Cree, Thomas S., 17 Exchange sq. 1869
Cross, David, 25 Park circus. 1850
150 Cumming, J. Simpson, M.D., 310 St. Vincent street. 1874
*Cuthbertson, John N., 29 Bath st. 1850

Dansken, A. B., 102 Bath street. 1877
*Dansken, John, 102 Bath street. 1876
Darling, Geo. E., 178 St. Vincent st. 1870
155 Davidson, T., Jun., 33 Garngadhill. 1872
Davis, Henry, 16 Blythswood square. 1881
Day, St. John Vincent, C.E., F.R.S.E., 115 St. Vincent street. 1866
Deas, Jas., C.E., 7 Crown gardens, Dowanhill. 1869
Dempster, John, 33 Abbotsford pl. 1875

160 Dennison, Wm., C.E., Land Surveyor, 175 Hope street. 1876
Dewar, Duncan, Kirkhill, Cambuslang. 1877
Dickie, James, 7 Claremont terrace. 1879
Dickson, James, 15 Binnie place. 1871
Dittmar, W., F.R.S.E., Professor of Chemistry, Anderson's College. 1875
65 Dixon, A. Dow, 10 Montgomerie crescent, Hillhead. 1873
Dixon, Edward M., B.Sc., 11 Hopeton place. 1860
Dixon, Joseph Anthony, 175 West George street. 1870
Dixon, Peter W., 19 Elmbank cres. 1871
Dobbie, James Johnston, M.A., D.Sc., Assistant to the Professor of Chemistry, University, 292 St. Vincent street. 1880
70 Dodds, Rev. Jas., D.D., 15 Sandyford place. 1876
Donald, John, Thomson street Public School. 1872
Donald, William J. A., 29 St. Vincent place. 1877
Donald, Alex. W., Colliery Salesman, Bank place, Cambuslang. 1880
Dougall, Franc Gibb, 167 Canning st. 1875
75 Dougall, John, M.D., F.F.P.S., Lecturer on Materia Medica in the Glasgow Royal Infirmary School of Medicine, 6 Belmar terrace, Shields road, Pollokshields. 1876
Douglas, Campbell, I.A., 266 St. Vincent street. 1870
Douie, Robert, 37 Bath street. 1869
Downie, James, North Bank house, Kirkintilloch. 1872
Downie, Robert, Jun., Carntyne Dye-works, Parkhead. 1872
80 Drew, Alex., 149 West George st. 1869
Dron, William, Cranstonhill. 1873
Dryburgh, Jas. N., 7 Matilda ter., Strathbungo, 1872
Duff, M. Campbell, 115 Wellington st. 1880
Duncan, Alex., B.A., 242 St. Vincent street. 1878
85 Duncan, Eben., M.D., C.M., F.F.P.S.G., 4 Royal crescent, Crosshill. 1873
Duncan, Robert, Engineer, Partick Foundry. 1875
*Dunlop, Nathaniel, 1 Montgomerie crescent, Great Western road. 1870
Dunn, John S., Rockvilla Saw Mills, Port-Dundas. 1876
Dunn, Robert Hunter, 4 Belmont crescent. 1878

90 Easton, Robert, C.A., 115 Buchanan street. 1880
Easton, Walter, 32 Exchange sq. 1878
Easton, William J., 150 West Regent street. 1876
Edward, David, 92 Buchanan st. 1878
Evans, Mortimer, C.E., F.G.S., 97 West Regent street. 1859

195 Fairlie, Colin B., C.E., 67 Renfield street. 1874
Fairweather, Wallace, C.E., Patent Agent, 96 Buchanan street. 1880
Falconer, Patrick, 128 Victoria st., Dowanhill. 1876
Falconer, Thos., 50 Kelvingrove st. 1880
Farquhar, John, 13 Belhaven terrace, 1872
200 Fawsitt, Charles A., 24 Richmond street. 1879
Fergus, And., M.D., M.R.C.S.Eng., 3 Elmbank cres. 1868
Fergus, Jas., 5 Burnbank gardens. 1880
Ferguson, John, M.A., Professor of Chemistry, University of Glasgow. 1869
Ferguson, Peter, 4 Linwood ter., Glasgow st., Hillhead. 1866
205 Fergusson, Alex. A., 48 M'Alpine st. 1847
Fife, William, Commission Merchant, 52 Glassford street. 1880
Finlay, Joseph, 9 Montgomerie drive, Kelvinside. 1873
Finlay, John, Moss Park, Albert road Pollokshields. 1850
Finlayson, Jas., M.D., 351 Bath st. 1873
210 Fisher, Donald, 183 St. Vincent st. 1869
Fleming, James, Earthenware Manufacturer, 7 Fitzroy place. 1880
*Fleming, William James, M.B., 155 Bath street. 1876
Forbes, Alex., Auchingramount road, Hamilton. 1879
Forbes, George, B.A., F.R.S.E., Professor of Natural Philosophy in Anderson's College. 1872
215 Foulds, John, L.D.S., 173 Bath st. 1877
Foulis, David, M.D., 191 Hill st. 1877
Foulis, William, C.E., 42 Virginia street. 1870
*Fowler, John, Builder, Kelvinbank terrace, Sandyford. 1880
Frame, Thomas, Royal Bank place. 1863
220 Frazer, Daniel, 113 Buchanan st. 1853
Frew, Alex., C.E., Land Surveyor, 175 Hope street. 1876
Frew, Robert, M.E., 75 Bath street. 1874
Fulton, David, Engraving Works, Duke street. 1872

Gairdner, W. T., M.D., Professor of Practice of Medicine in the University of Glasgow, 225 St. Vincent street. 1863
225 Galbraith, Andrew, 123 Hope st. 1857
Galbraith, William, 3 Blythswood square. 1868

Gale, Jas. M., C.E., Water Office,
23 Miller street. 1856
Galloway, T. Lindsay, C.E., 28 St.
Enoch square. 1881
Gardner, Daniel, 36 Jamaica street. 1869
230 Garroway, John, 58 Buchanan st. 1875
Garroway, Robt., M.D., Rosemount,
Cumbernauld road. 1859
Geddes, Wm., Battlefield, Langside. 1846
Gemmell, Wm., 150 Hope street. 1876
Gentles, Wm., 338 Sauchiehall st. 1870
235 Gillies, Wm., Battlefield, Langside. 1869
Gillies, W. D., 96 Miller street. 1872
Gilmour, J. B., 50 North Hanover
street. 1865
Gilfillan, Wm., Marble Cutter, 129
St. Vincent street. 1881
Glaister, John, M.B., 16 Grafton
square. 1879
240 Goodwin, Robert, 58 Renfield st. 1875
Gorman, William, 153 West Nile st. 1860
Gossman, Adam, 79 Robertson st. 1870
Gourlay, John, C.A., 24 George
square. 1874
Gourlay, Robert, Kirklee avenue,
Great Western road. 1869
245 Gow, Alexander, 117 Ladbrooke
Grove Road, Notting hill, London, W. 1869
Gow, Robert, Cairndowan, Dowanhill gardens. 1860
Graham, David, Jun., 140 Douglas
street. 1876
Grant, Robt., M.A., LL.D., F.R.S.,
Professor of Astronomy in the University of Glasgow, Observatory,
Hon. Vice-President. 1860
Gray, Charles, 193 Renfrew street. 1870
250 Gray, James, M.D., 15 Newton
terrace. 1863
Gray, James, 12 Kelvingrove street. 1876
Greenlees, Alex., M.D., 405 St.
Vincent street. 1864
Grierson, James, 4 Westbourne gardens, Kelvinside. 1880
Grieve, John, M.D., care of W. L.
Buchanan, 212 St. Vincent st. 1856
255 Grieve, Robert, L.R.C.S., Ed., 52
Holmhead street. 1872

Hamilton, Geo., 149 St. Vincent st. 1871
Hamilton, J. Struthers, Adelphi
Cotton Works. 1869
Hamilton, Patrick, 149 St. Vincent
street. 1854
Hamilton, David C., Engineer, 2
Oswald street. 1880
260 Hannay, Anthony, 23 Exchange
square. 1856
Hannay, Jas. B., F.R.S.E., F.C.S.,
Annfield Chemical Works, Sword
street. 1879
Hannay, Thos., 166 Buchanan st. 186[illegible]
Hannay, W. H., Clyde Oil Works,
Crownpoint road. 1876
Hannay, Maxwell, 104 West George
street. 1881
265*Harvie, John, Secretary, Clydesdale
Bank, 30 St. Vincent place. 1880
Hay, John, 12 Terrace street. 1870
*Henderson, John, Jun., 4 Crown
terrace, Dowanhill. 1879
Henderson, Thos. Brown, M.D.,
17 Elmbank crescent. 1880
Henderson, Thos., 47 Union street. 1855
270 Henderson, Wm., 13 Annfield terrace, Partickhill. 1853
Henderson, Wm., 15 Cadogan st. 1873
*Henderson, A. P., Engineer and
Shipbuilder, 10 Crown terrace,
Dowanhill. 1880
Henry, R. W., Foremount terrace,
Partick. 1875
Hewat, A., F.F.A., 41 Elmbank
street. 1877
275 Heys, Zechariah J., South Arthurlie,
Barrhead. 1870
Higginbotham, James S., 104 W.
George street. 1874
Higgins, Henry, Jun., 243 St. Vincent street. 1878
Hill, Andrew, 31 Arlington street. 1877
Hilliard, Joseph, 65 Renfield street. 1878
280 Hislop, James Daniel, Montgomerie
drive. 1874
Hodge, William, 15 Hillsborough
square, Hillhead. 1878
Hoey, David G., 124 St. Vincent
street. 1869
Hogg, Robert, 15 Cadogan street. 1865
Holt, T. G., 25 Wellington street. 1875
285 Honeyman, John, F.R.I.B.A., 140
Bath street. 1870
Horne, R. R., C.E., 150 Hope st. 1876
Howatt, James, 146 Buchanan st. 1870
Howatt, William, 146 Buchanan
street. 1870
Hunt, Edmund, 87 St. Vincent
street. 1856
290 Hunter, A. C., 197 St. Vincent
street. 1880
Hunter, James, Newmains house,
Motherwell. 1854
Hunter, James, 156 St. Vincent st. 1874
Hunter, J. E., 30 Hope street. 1878
Hutcheson, Robt., 8 Great Western
terrace. 1868
295 Hutton, W. R., 149 Hill street,
Garnethill. 1868

Inglis, Anthony, 64 Warroch street. 1854
Inglis, John, 64 Warroch street. 1850
Irvine, A. K., M.D., 3 Newton
terrace. 1858

illiam, LL.D., Professor of
matics in the University of
w. 1881
Villiam, 7 Exchange place. 1875
Thomas, Western Club. 1857
ustav, Prospect Villa, Mont-
y terrace, Mount Florida. 1871
, And., C.E., Principal of
of Science and Arts. 1881
, John L. K., 9 Crown ter.,
hill. 1868
Joseph O., District Manager
al Telephone Co. (Lim.),
al Exchange square. 1881
Rev. J. S., D.D., Manse,
slang. 1870
e, Jas., Coatbridge street,
undas. 1869
illiam, 286 Bath crescent. 1871

, Hugh, Redclyffe, Partick. 1876
, Thos., 42 Ingram st. 1869
, Walter Stewart, Allan-
Crosshill. 1873
lliam, 1 Windsor terrace,
1874
arles James, Greenfaulds
Cumbernauld. 1877
mes Hy., 13 Virginia st. 1872
hn G., M.A., Allister Cot-
ambuslang. 1878
liam, Tradeston Gas-works. 1877
mes, 57 Hamilton drive,
d. 1848
mes, of Levernholm, 115
gton street. 1855
exander C., 17 Hillsboro'
Hillhead. 1869
obert, M.D., Newton cot-
artick. 1877
ick, Andrew J., 10 Wood-
ce. 1869
d, Anderson, LL.D., 7
e terrace, Stirling. 1869
ohn, 98 Argyle street. 1855
. E., B.A., F.G.S., F.C.S.,
ad Forge. 1880
dam, Engineer, 47 Crown-
oad. 1881
ndrew L., Montgomerie
Kelvinside, Great Western
1868
hn, 129 West George st. 1870

David, Chaseley, Skel-
1879
lex., LL.D., Professor of
matics in Anderson's Col-
1846
o., 10 Ann st., Bridgeton. 1870
ohn, Marchmont, Port-
w. 1876

Laird, John, Royal Exchange Sale Rooms. 1879
Lamb, Thomas, 190 Parliamentary road. 1870
Lang, William, Jun., Crosspark, Partick. 1865
335 Leggatt, Robert, 38 Sauchiehall st. 1869
Lamont, Henry, 93 Hope street. 1880
Latta, James, 8 Miller street. 1869
Latta, John, 138 W. George street. 1880
Lawson, John, Cranstonhill. 1880
340 Leisler, Louis, 130 Hope street. 1869
Lindsay, Archd. M., M.A., 87 West Regent street. 1872
Lindsay, Wm. G., 30 George square. 1871
Livingston, Robert, 263B Argyle st. 1879
Long, John Jex, 12 Whitevale. 1862
345 *Lothian, J. Alexander, M.D., L.R.C.S.E., 6 Newton terrace. 1872
Low, James, 176 St. Vincent st. 1878

M'Alley, Robert, Chemical Works, Falkirk. 1872
M'Andrew, John, 17 Park st., East. 1843
M'Arthur, Alex., 82 Glassford st. 1865
350 Macarthur, J. G., 7 West Princes street. 1874
M'Call, J., F.R.C.V.S., Prof. of Veterinary Medicine and Surgery, Veterinary College, 85 Buccleuch street. 1866
M'Callum, George, Rossbank, Cambuslang. 1850
M'Clure, David, Letterpress Printer, 62 Argyle street. 1880
M'Conville, John, M.D., 11 Elmbank crescent. 1870
355 M'Crae, John, 7 Radnor street. 1876
M'Creath, James, M.E., 95 Bath street. 1874
M'Culloch, Richard, 157 St. Vincent street. 1872
M'Culloch, William, 50 Westbourne gardens, West. 1872
M'Culloch, Hugh, House Painter, 102 West Regent street. 1880
360 Macdonald, Arch. G., 8 Park circus. 1869
Macdonald, Thomas, 109 Bath st. 1869
M'Ewan, Wm., Jun., 17 St. Vincent lane. 1869
Macfarlane, James Lilburn, Meadowbank, Torrance of Campsie. 1876
Macfarlane, Samuel, Meadowbank, Torrance of Campsie. 1876
365 Macfarlane, Walter, Saracen Foundry, Possil Park. 1855
M'Farlane, Walter, Printworks, Thornliebank. 1869
M'Gavin, John, 19 Elmbank place. 1869
M'Gill, J. S., Ardendrian, Windsor circus. 1869
M'Gilvray, R. A., 65 Bath lane. 1880

370 M‘Gregor, Duncan, F.R.G.S., 45 Clyde place. 1867
M‘Gregor, Jas. W., 4 Gt. Western terrace, Hillhead. 1869
M‘Gregor, James, 1 East India avenue, London, E.C. 1872
M‘Grigor, Alexander B., LL.D., 172 St. Vincent street. 1857
*M‘Ilwraith, James, 4 Westbourne terrace, Kelvinside. 1872
375 M‘Intyre, Peter, 26 Ingram street. 1873
Mackay, John, Jun., 354 Sauchiehall street. 1869
*M‘Kenzie, W. J., Oakfield terrace, Hillhead. 1870
*M‘Kenzie, W. D., 43 Howard st. 1875
M‘Kendrick, John G., M.D., C.M., F.R.C.P.Ed., F.R.S.E.L., Professor of Institutes of Medicine in the University of Glasgow, 33 Westbourne gardens, *Secretary*. 1877
380 Mackinlay, David, 6 Great Western terrace, Hillhead. 1855
M‘Kissack, John, Architect, 175 St. Vincent street. 1881
M‘Laren, Robert, Canal street, Port-Eglinton. 1848
M‘Laren, William Ed., 13 Exchange place. 1873
Maclay, David T., 169 W. George street. 1879
385 Maclean, A. H., 124 Queen street. 1870
Maclehose, James, 18 Victoria cres., Dowanhill. 1867
Maclellan, A. H., 6 Lansdowne cres. 1870
M‘Lellan, Lewis, 7 Belhaven ter. 1869
M‘Lellan, Walter, 129 Trongate. 1856
390 M‘Leod, Kenneth M., 1 Montrose street. 1870
Macleod, D. M., Merchant, 8 Victoria terrace. 1881
M‘Nicol, Peter, M.A., 14 Derby terrace. 1873
M‘Onie, Andrew, Scotland street, Tradeston. 1860
Macphail, Donald, M.B., 9 W. Princes street. 1877
395 M‘Pherson, George L., 17 Albert drive, Crosshill. 1872
Mactear, James, F.C.S., St. Rollox Chemical Works. 1867
M‘Vail, D. C., M.B., 400 Great Western road. 1873
Macvicar, A., Shields cottage, Pollokshields. 1876
Maddiver, Dr. John C., Sen., 19 Battery place, Rothesay. 1881
400 Main, James, A. R., 25 Hope street. 1870
Manford, Stewart, 5 Dixon street. 1874
Mann, John, C.A., 154 St. Vincent street, *Treasurer*. 1856
Manwell, James, 2 Albert road, Pollokshields. 1876
*Marshall, James, Carlston, Kelvinside. 1869
405 Martin, Thos., 166 Sauchiehall st. 1862
Martin, Thos., 19 Rupert st., Great Western road. 1871
Marwick, J. D., LL.D., F.R.S.E., Killermont House, Maryhill. 1878
*Mason, Stephen, 47 Queen street. 1870
Mathieson, John A., 14 Sardinia terrace, Hillhead. 1851
410 Mathieson, Thomas A., 13 East Campbell street. 1869
Mayer, E. L., 12 Hillhead gardens. 1872
Mayer, John, F.C.S., 2 Clarinda terrace, Pollokshields. 1860
Mechan, Arthur, 118 Cheapside street. 1876
Mechan, Henry, 118 Cheapside st. 1879
415 Menzies, Thos., Hutchesons' Grammar School, Crown street. 1859
Michaelson, M., 3 Sandyford place. 1878
Middleton, Robert T., M.P., 179 West George street. 1860
Millar, David, Laurel green, Helensburgh. 1873
Millar, Jas., 134 Parliamentary rd. 1870
420 Millar, William, 3 Woodside ter. 1873
Miller, A. Lindsay, 121 W. Regent street. 1878
Miller, Daniel, C.E., 203 St. Vincent street. 1851
Miller, Hugh, M.D., F.F.P.S., 298 Bath street. 1872
Miller, Jas., Port-Dundas Pottery. 1863
425 Miller, James, 21 Woodside place. 1869
Miller, John (Messrs. James Black & Co.), 23 Royal Exchange sq. 1874
Miller, John, 179 West George st. 1879
Miller, Thomas, Maxwell terrace, Pollokshields. 1876
Miller, Thos. P., Cambuslang Dye-works. 1864
430 Miller, W. M., 5 Shaftesbury ter., West Regent street. 1867
Mills, Edmund J., D.Sc., F.R.S., Anderson's College. 1875
Milne, William, Mathematical and Science Master, High School. 1881
Mirrlees, James B., 45 Scotland street, Tradeston. 1869
Mitchell, Angus, 42 Miller street. 1872
435 Mitchell, Jas. L., 10 Gt. Western terrace. 1876
Mitchell, Robert, 54 Carnarvon st. 1870
Moffatt, Alexander, 47 Union st. 1874
Montereau, Emile Louis de, 107 Pollok street. 1877
Moore, Alexander, C.A., 128 Hope street. 1869
440 Moore, Robert H., 3 Armadale st. 1876

, William, M.E., 49 West rge street. 1860
n, John, Springfield house, opbriggs. 1844
e, Alexander, Tullymet villa, on road, Pollokshields. 1873
on, Donald, LL.D., 4 Victoria ace, Dowanhill. 1877
on, Geo., 21 Athole gardens, rinside. 1872
on, George R., 12 Colebrooke rt, Hillhead. 1875
on, James, 98 Sauchiehall st. 1869
n, Alexander, 241 W. George st. 1869
n, James, M.D., Professor of eria Medica in Anderson's ege, 199 Bath street. 1868
n, James, Turkey-red Works, uhurn, Renton, 1876
an, John, 21 Elmbank cres. 1870
, John, 12 Montgomerie ter- , Kelvinside. 1881
John, 6 Park gardens. 1876
Thomas, M.A., F.R.S.E., h croft, Bishopton, *Vice-ident*. 1874
William R., 345 Bath cres. 1877
Allan, Plumber and Brass-der, 36 George street. 1881
ead, Andrew Erskine, Cart e, Crossmyloof. 1873
ead, Henry, M.D., Bushy Hill, buslang, *Vice-President*. 1869
ead, Robt. Franklin, B.Sc., Renfrew street. 1879
, Daniel, 7 Park quadrant. 1867
e, George, 1 St. John's ter., head. 1871
ch, James, Glenneuk, Port-gow. 1857
ch, Jas. B., Hamilton place, side, 1855
ch, Robert, 16 Main street, als. 1880
ch, Wm., 30 Hope street. 1879
y, David, 169 West George st. 1876
y, George, 8 Ingram street. 1872

Archibald, 63 North Fred- street. 1870
, James, F.C.S., F.R.S.E., yfield, Bothwell. 1849
, James, Jun., Maryfield, well. 1870
, John, Saughfield house, head. 1849
n, Walter, 172 West George st. 1856
n, Walter M., Queenhill, ford, Kirkcudbrightshire. 1843

Neilson, Wm., 58 Bath street. 1871
475 Nelson, D. M., 48 Gordon street. 1875
Nelson, Alex., 8 Prince's square. 1880
Neuhaus, Albert, 1 Prince's terrace, Dowanhill. 1874
Newman, David, M.B., C.M., Pathological Chemist, Western Infirmary, 12 Annfield terrace, Partickhill. 1877
Nicol, David, 2 Teviot terrace, Kelvinside. 1872
480 Nicol, James, City Chambers, 1872
Nowery, William, 37 Derby street. 1876

Ogilvie, Thomas Robertson, F.C.S., 13 Forsyth street, Greenock. 1875
Osborne, Alex., 5 Oakley terrace, Dennistoun. 1870
Outram, D. E., 16 Grosvenor ter., Hillhead. 1878

485 Paris, Wm., Glasgow Iron Works, St. Rollox. 180
Paris, William, Jun., Glasgow Iron Works. 1872
Park, James, Millburn Chemical Works. 1877
*Parnie, James, 26 Lynedoch street. 1874
Paterson, Adam, LL.D., 45 West George street. 1843
490 Paton, James, F.L.S., Corporation Galleries, and Kelvingrove Museum. 1876
Patterson, T. L., F.C.S., at John Walker & Co.'s, Greenock. 1873
Paterson, Robert, C.A., 28 Renfield street. 1881
Paton, Hugh, Warehouseman, 61 Miller street. 1880
Pennycook, C. H., Queensberry terrace, Langside. 1869
495 Pettigrew, Wm. S., 17 Queen's crescent. 1880
Pinkerton, R. H., M.A., Mathematical Lecturer, University, 46 Bank street, Hillhead. 1880
Pirie, John, M.D., 26 Elmbank crescent. 1877
*Pirrie, Robert, 9 Buckingham ter. 1875
Pollock, Arthur, Dillichip Works, Alexandria. 1879
500 Poynter, John E., 8 Prince's square, Buchanan street. 1866
Pringle, Quintin, B.Sc., B.A., LL.B., 25 Belmont street, Hillhead. 1872
Provan, James, 69 St. Vincent st. 1868
Purvis, Robert T., 34 Claremont st. 1879

Ramsay, John, of Kildalton, M.P., 5 Dixon street. 1856
505 Ramsay, William, C.E., 11 Ashton terrace, Dowanhill. 1841

Ramsay, Wm. Craig, Writer, 134 St. Vincent street. 1881
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515 Reid, J. G., 2 Sandyford place. 1874
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520 Reith, Rev. George, M.A., Free College Church, 13 Bowmont gardens, Kelvinside. 1876
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545 Russell, James B., B.A., M.D., 1 Montrose street. 1862
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585 Spence, John M., Ardlin, Helensburgh. 1881
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605 Stewart, David Y., Barrassie bank, near Troon. 1849
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635 Thomson, James, F.G.S., 3 Abbotsford place. 1863
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640 Thomson, James R., Clydebank Foundry. 1863
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645 Townsend, Joseph, 13 Crawford st., Port-Dundas. 1856
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650 Ure, John, Crown Mills, 68 Washington street. 1856
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ROBERT ANDERSON, PRINTER, 22 ANN STREET.

PROCEEDINGS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW.

SEVENTY-NINTH SESSION, 1881-82.

Opening Address. By Dr. WILLIAM WALLACE, President.

[Read before the Society, November 2nd, 1881.]

GENTLEMEN,—In opening the Seventy-ninth Session of the Philosophical Society, I have to congratulate you on the success of the past winter, and the favourable prospects of that on which we have now entered. In accordance with the custom in this and other learned societies, I propose to engage your attention this evening with some remarks of an introductory character; but, when I call to remembrance the eminent men who have occupied the chair on former similar occasions, I may well feel some misgivings as to my fitness to deliver the inaugural address of the present session. Of such men as Thomas Thomson, Henry Rodgers, Allen Thomson, Thomas Anderson, Macquorn Rankine, Walter Crum, Sir Wm. Thomson, Professor Grant, and Andrew Fergus—each in the very foremost rank of his own profession—any scientific society might well be proud, and the brilliant lustre shed by such luminaries cannot fail to cast into deep shadow the efforts of any man of commonplace position or abilities.

Among the branches of science represented in our Society none has played a more conspicuous part than chemistry. From an early date in the century down to a period within my own membership, Dr. Thomas Thomson, Professor of Chemistry in the University of Glasgow, reigned as perpetual president; and no one, however eminent in science, literature, or art, could at that time hope to attain to anything higher than the office of vice-president, secretary, treasurer, or librarian. Among these officers of the Society Dr. R. D. Thomson, the nephew and son-in-law of Professor Thomson—and who was virtually, although not actually, Professor of Chemistry during the later years of his uncle's life—played a conspicuous part, as well as Walter Crum and other chemists of reputation. Later on the president's chair was ably filled by Professor Anderson; and his successor, Professor Ferguson, as president of the Chemical Section, has contributed several very valuable memoirs, chiefly of an historical character. My own connection with the Society dates back some thirty years, although I contributed work which was brought before it at a still earlier date.

In the absence of any new and startling discovery in one's own particular department, there is always a difficulty in selecting for an opening address a subject which will at once possess sufficient interest to be listened to with attention by a mixed audience, composed of workers in all the various branches of science and art, and at the same time be of a nature consistent with the dignity of a learned society. Under these circumstances, it is a not uncommon practice to fall back on a *resumé* of the progress of science generally during the previous year, or decade, as the case may be, or since the society came into existence. I will not, however, attempt to follow this course on the present occasion—firstly, because I am but little qualified to undertake such a task, and, secondly, because I consider it more profitable to confine your attention to-night to one phase of that branch of physical science with which I am most acquainted—chemistry.

There are in chemistry two great and leading methods of research which have contributed equally to the advancement of our knowledge of the relations of the various elements to one another. One of them is called analysis, or decomposition, or dissociation—although the last-named term expresses analysis in a somewhat restricted sense; the other is denominated synthesis, or combination. It is to the first of these methods of inquiry that I shall ask you to follow me in the remarks I shall address to you, and chiefly in the more limited sense implied in the term dissociation.

The word analysis in chemistry signifies a separation or splitting up of a body into its component parts, such separated parts differing from each other and from the original body from which they were taken. This definition of analysis at once distinguishes chemistry from physics in the restricted application of the word. If we take a piece of marble, we can examine it either physically or chemically. In the first case, we may estimate the exact size of the stone, its absolute weight in pounds, grammes, or grains, as the case may be, its weight, as compared with that of an equal bulk of water, or specific gravity, as it is usually termed; its relations to light, heat, and electricity; its comparative hardness, and many other qualities. We may also, by mechanical means, break the lump in pieces and reduce it to powder; but each minute fragment will still be a piece of marble, unchanged in all its properties. But how different is a chemical examination! The application of an acid at once discloses the fact that the mineral contains a gas, and also a body which dissolves in the acid, forming a clear solution, from which it may afterwards be obtained by appropriate means. This is analysis or decomposition. The same mineral—which is simply one of the many forms of limestone—if exposed to a full red heat in a furnace, is separated into its constituents: lime remains behind, while carbonic anhydride, or, as it is commonly called, carbonic acid gas, escapes with the products of the combustion of the coal, although it can readily, by appropriate means, be collected and its properties examined. This is dissociation, or the separation of a compound body into its constituents, without the intervention of any other chemical agent. By various methods—some extremely simple, others highly complex—all substances, animal, vegetable, and mineral, within our reach, have been analysed or decomposed, or dissociated, until we have arrived at a number of bodies which we call elements—about 65 in number—which we have never yet been able to tear asunder into any simpler form of matter. Of these the greater number are metals, while a comparatively small proportion—about one-fifth of the whole—are either gaseous or possess properties of an opposite character to those of the metals. Among the latter, I may mention sulphur, phosphorus, iodine, bromine, and carbon. The distinction between the metals and non-metallic elements is not, however, so precise and absolute as might at first be supposed; phosphorus is closely allied to the metal arsenic, the metal chromium forms compounds like those of sulphur, and there are many other singular analogies. It was long accepted as an axiom in chemistry that the gas hydrogen was a metal, or acted the part of one; but it has, within the last few years, actually been condensed by intense pressure and extreme cold into a liquid, and even into a solid metal. Of this, however, I shall speak further on.

The forces by which bodies may be dissociated are various, but by far the most important is heat. In many cases compounds appear to have their constituents grouped together so loosely that the most insignificant application of force suffices to break them up. Thus the compounds usually called chloride and iodide of nitrogen (consisting of ammonia, the hydrogen of which is more or less completely replaced by chlorine or iodine) explode with violence on being touched with a feather, or by mere agitation of the air by which they are surrounded. The green hydrated oxide of copper holds its combined water so feebly that, on heating to the boiling point, even below water, it is separated, and the black anhydrous oxide is produced. A weak solution of the crystallized chloride of cobalt, on being heated to boiling in a sealed tube one-third full, changes from the hydrated to the anhydrous condition, the separation of the water of hydration being made apparent to the eye by the liquid changing from pink to blue. Many ammoniacal salts become dissociated to a certain extent on their solutions being heated. The oxides of mercury are readily decomposed at a low red heat (600° to 700° F.), and those of silver, gold, and platinum all give off their oxygen, leaving the metals in a pure condition, on exposure to a moderate heat. In other cases the decomposition is only partial, as when the black or binoxide of manganese is converted into the lower brown oxide, when chromic acid gives off half its oxygen, and becomes the green oxide of chromium, when iron pyrites gives off part of its sulphur; and many other cases of a similar nature.

Heat is only one of the many forms of force by which compound bodies are affected. Light has a distinct power of decomposing many chemical compounds. The salts of silver are particularly sensitive to light, and the art of photography depends entirely upon the effect of light on silver salts and other compound bodies. Vegetable colours are also readily changed by light, but by far the most important function played by light in decomposing compound bodies is displayed in the phenomena of plant life, in which carbonic anhydride, water, and ammonia are decomposed; and their elements rearranged, so as to give rise to an infinite multitude of new combinations; while oxygen gas is freely given off.

Electricity is a potent agent of dissociation, and is frequently used by the chemist, especially for the separation of metals from their solutions. One of the most familiar illustrations of the action of voltaic electricity upon chemical compounds is the decomposition of water, in which the two gases of which it is composed—oxygen and hydrogen—pass off from the two electrodes or terminals of the wires of the battery. A convenient form of the arrangement, as a lecture illustration, is that in which the gases, as they stream off, are collected in graduated tubes, so that the analysis is really quantitative. Although it is wandering a little from our subject, it may be interesting to consider for a moment how it is that the gases appear at the two poles, which may be many inches apart. If we take a molecule of water, composed of one atom of oxygen and two atoms of hydrogen, and suppose this molecule to occupy a position in close contact with one of the poles, we can understand how one of the gases, say the oxygen, is evolved at that pole : but how does the hydrogen travel to the other pole? The answer to this is, that it does not travel at all, but unites with the oxygen of the nearest molecule of water in the direction of the current, which in turn gives up its hydrogen to the next molecule, and so on until the other pole is reached and the gas is disengaged. We have, as it were, a polarization of the water, by virtue of which we may conceive that a series of molecules are distorted so as to have their oxygen pointing in one direction and their hydrogen in the other, the ultimate effect being as I have stated.

I may make another digression, but only for a moment, to ask your attention to the terms atom and molecule. With regard to atoms, we know the *relative* weight of these, and, in the case of gases, their *relative* dimensions, but of their actual weight or size we are, and must ever remain, in ignorance. It is true that in the case of certain elementary gases, mathematicians have made estimates of their probable size (for example, it has been calculated that the atom of hydrogen does not exceed one five-millionth of an inch in diameter); but even in such estimates as these we cannot tell whether we are dealing with ultimate atoms or molecules composed of an aggregation of atoms. It is certain that some gases, such as chlorine and iodine vapour, are composed of molecules or grouped atoms, since these can be dissociated by heat, the gases expanding in volume when the dissociation takes place. Neither can we tell whether elements, in combining together, unite atom to atom or molecule to molecule. In water, one of the simplest of chemical compounds, since it contains only two elements, we have oxygen and hydrogen in the proportion of one atom of the former to two atoms of the latter. But we cannot tell how these atoms are grouped. We can represent it with an atom of oxygen in the centre, with one of hydrogen on each side, or with one of oxygen above and a double atom of hydrogen below; but these are not at all likely to be correct. It is almost absolutely certain that the molecule of water has a geometric or solid figure, which could not be made up of less than six atoms, and probably is much more complex. A system of representations of compound bodies by diagrams, called *graphic formulæ*, have for some years been employed by some of our leading chemists, and are said to be useful in teaching the science. To my mind they form a stumbling-block rather than an assistance to the student, who is constantly confronted with representations of arrangements which cannot by any possibility exist in nature.

Other examples of the dissociation of compounds by electrical agency might be mentioned. Hydrochloric acid is easily decomposed, hydrogen gas being given off at one pole and chlorine at the other; but the chlorine, being soluble in the liquid hydrochloric acid to some extent, is not immediately evolved in the gaseous state. Its presence may, however, be evidenced by its bleaching action upon vegetable dyes—indigo, for example, being at once decolorized by the electrolized hydrochloric acid. In like manner hydriodic acid is decomposed by the electrical current—or, what amounts to the same thing, a solution of potassium iodide acidulated with hydrochloric acid. On passing the current, iodine is immediately set free, and may be distinguished by forming a blue compound with starch, while hydrogen is disengaged at the opposite pole.

In the practical arts the deposition of metals has now become an industry of enormous dimensions. The manufacture of electro-plate alone engages thousands of operatives in Birmingham, Sheffield, and other towns; and, among other branches of the art, I may mention electro-gilding, and the deposition of copper, brass, and nickel—the last a comparatively new industry, which is rapidly assuming large proportions. In these cases the battery has been replaced by the steam-engine, the mechanical force of which is converted into the electric current by the magneto-electric machine, where permanent magnets are employed, or the dynamo machine, in which electro-magnets are used.

The fact of metals being constantly set free at one pole of a battery, while what we call, for want of a better name, non-metallic elements, appeared at the other, led many years ago to the introduction of the term electro-positive elements for the metals, including hydrogen, and electro-negative for the opposite group, including chlorine, iodine, bromine, fluorine, oxygen, sulphur, and so on. These terms, however useful in their time, are scarcely, if at all, used by chemists at the present day.

To return to the action of heat in its action upon chemical compounds—I have now to carry you a little further. We have seen that many compounds are readily decomposed; but there are others which require the highest temperature at our command for their decomposition. Until very recently water was supposed to be incapable of being separated into its elements by heat alone. By an ingenious contrivance Sir William Grove succeeded in effecting the resolution of this compound, and in this way:—In a flask water was made to boil, and in a tube which received the steam a succession of electric sparks were passed from a Ruhmkorff coil, and the steam further on was condensed, while the gases formed by the dissociation of the watery vapour by the intense heat of the electric spark were carried forward by an aspirator or Sprengel pump into an appropriate receiver. In this case the gases, once separated, were pushed on by the large volume of steam, otherwise they would have recombined. In many experiments in the laboratory we use the electric spark to explode mixtures of oxygen and hydrogen, and it is, in fact, the only means we can employ if we have to measure the amount of condensation which follows the explosion. We can readily produce, in furnaces, degrees of temperature amply sufficient for the decomposition of water (2,000° C., or 3,632° F.), and there is not the slightest doubt that such decomposition is constantly taking place; but the gases are immediately recombined. But there are complications in this case—the carbon of the fuel reacts upon a portion of the watery vapour, and carbonic oxide and carburetted hydrogen result, which, on the top of the fuel, burn to carbonic acid and water—exactly the same result following as if there had been no decomposition of the water. As the heat absorbed or rendered latent in the act of decomposition is exactly equivalent to that which results from the subsequent combustion, it follows that the introduction of steam into a furnace does not increase the gross amount of heat due to the combustion of the fuel, but it frequently has the useful effect of carrying forward in the furnace the zone of highest temperature, and so serves a useful purpose.

Perhaps the most important example of dissociation presented to us within a comparatively recent period is that of carbonic acid gas, which was effected by Deville in 1868. This eminent chemist showed that at an extremely high temperature carbonic acid (CO_2) is dissociated into carbonic oxide (CO) and oxygen. Further than this, CO is decomposed, two atoms of it giving one atom of carbon and one atom of carbonic anhydride, the ultimate result being the resolution of the original compound into carbon and oxygen. A peculiar arrangement is required for the performance of this process—a ring of metal kept cold by a current of water being close to the gases, heated to an intense degree by the electric spark, and the carbon is deposited upon the cold metal. I consider this a most important discovery, not merely as a scientific fact, but as an explanation of phenomena which could not otherwise be accounted for. In an ordinary furnace, such as those employed in the Siemens-Martin process, and others in which an intense heat is obtained, there is evidently a limit beyond which no further increase of temperature can be obtained—for this reason, that carbon and oxygen refuse to combine at a very exalted temperature, the exact degree of which we cannot exactly define, but which has been estimated at about 5000° F.

In the compounds of carbon and hydrogen we have a more familiar illustration of dissociation. If we pass one of the gaseous hydrocarbons, containing a large proportion of carbon—such, for example, as ethene (C_2H_4), popularly known as olefiant gas, or the vapour of a liquid hydrocarbon such as benzene, or of a solid such as napthalene—through a glass tube heated to bright redness, a deposit of carbon takes place, and the gas or vapour that passes on contains a greater or less proportion of methane or marsh gas (CH_4). This is a well known fact in some manufacturing processes. In gas-making, the retorts, especially at the back, become coated, often to the extent of several inches in thickness, with a solid deposit of carbon, which results from the decomposition of the gaseous liquid and solid hydrocarbons evolved from the coal by the action of heat. We may go further than this, and say that the production of illuminating gas from coal is itself an illustration of dissociation, for carbon is left behind, mixed with the mineral matter of the coal, forming coke, while the hydrogen and oxygen combine with a portion of the carbon, forming gaseous and liquid hydrocarbons and carbonic oxide, besides some other compounds containing sulphur and nitrogen. Again, if we distil coal tar or crude paraffin oil we obtain in the retort or still a portion of solid carbon, and a distillate of oils, containing less carbon than the original liquid. If we bring paraffin oil drop by drop, or in a thin stream, into a gas retort heated to bright redness, a thin and poor gas is obtained, and much solid carbon is set free, but at a low red heat a rich gas is produced, with no carbonaceous deposit. But to pursue this subject further, marsh gas, by exposure to a still higher temperature, either by the electric spark or in a porcelain tube placed in a furnace, yields hydrogen and a richer hydrocarbon, acetylene (C_2H_2), which in turn is decomposed into carbon, hydrogen, and some marsh gas, the ultimate result being that all hydrocarbons are resolvable by heat alone into carbon and hydrogen.

I could dwell on this subject much further, but it is unnecessary. Let us see now to what conclusion these experimental results lead us. It is simply this—that by the action of heat all compound bodies are resolvable into their elementary constituents, and that if we had a world, or planet, or sun, the temperature of which was sufficiently high, we should there have simply a collection of elementary bodies. That is a conclusion to which we are forced by experiment and analogy. Some of us may not be able to realise the existence of such conditions as I have stated as being necessary, but we must acknowledge that, if such conditions did exist, the result would follow, just as we accede to the statement that if water is exposed to a sufficiently low temperature it will freeze.

We now come to a division of our subject which is not chemical but physical, but which is nevertheless closely connected with the dissociation of compound bodies. We have in nature three states of matter—solid, liquid, and gaseous; but these are merely accidental conditions, as I shall attempt to show you, determined partly by the nature of the bodies themselves, partly by the particular temperature and pressure to which they are subject. I think you will have no difficulty in accepting the axiom that all solid bodies are capable of being liquified, if we except a comparatively small number which pass at once from the solid to the gaseous state, such as metallic arsenic, some of the compounds of arsenic and of mercury, &c. Platinum, which resists the heat of our ordinary furnaces, melts like wax before the oxyhydrogen flame; and in a crucible of pure lime—as suggested by Deville, and wrought out practically by Johnson, Matthey, & Co., of London—pounds, [illegible] may be fused with as [illegible] an iron ladle over a [illegible] than platinum, may [illegible] and all metals without [illegible] when placed in a voltaic [illegible] that they cannot pass it [illegible] with one liquid metal— [illegible] it is a malleable solid. [illegible] and indistinguishable [illegible] Again we are equally [illegible] —which are soft to [illegible] with the greatest facility. [illegible] of the earth in the plastic [illegible] when brought up to a welding [illegible] the point of fusion. [illegible] the beginning of the [illegible] temperature of boiling water [illegible] when exposed to intense [illegible] degree of heat 442 F. [illegible] latter assuming a little [illegible] which it may be [illegible] is readily [illegible] It is worthy of [illegible] in melting contract in [illegible] floats on the top of [illegible] accepted as [illegible] some of them make [illegible] shown that in a [illegible] of the surface [illegible] metal will sink in the [illegible] temperature [illegible] A similar experiment [illegible] there is [illegible] the fused mass [illegible] increasing its [illegible] its specific gravity. The explanation of this phenomenon is probably that, in assuming the solid state, the atoms or molecules take a geometric form, in which they occupy more space than they do when in a free condition of molecular movement, as they are when in the liquid state.

All liquids are capable of being boiled or converted into gases or vapours by heat, the only exceptions being in the case of those compounds which, on being heated, suffer decomposition. It is equally the case with solids, with the same exception, so that the gaseous form may be regarded as the normal condition of matter. There are many solid bodies which we have not actually as yet converted into gas, and we are compelled to fall back on analogies for proof of our proposition. The liquid metal mercury can be distilled like water, although the temperature required is considerably higher; potassium and sodium are converted into vapour with almost equal facility, and zinc is regularly distilled in the commercial production of that metal from its ores. Lead also is distinctly volatile, and no metal, however refractory, can be kept long at its melting point without suffering some loss of weight. Iron is readily volatilized, in part, by the heat generated by its own combustion in oxygen gas. Arsenic, on being heated, sublimes, passing at once into the gaseous condition without assuming the liquid form. Gold, which requires a rather high temperature for fusion, is at once dissipated in the gaseous state by an electric discharge of high tension; and silver, platinum, copper, iron, and many other metals are vaporized instantaneously with equal facility. With regard to carbon, there can be little, if any, doubt in the minds of scientific men that it is converted into vapour in the electric arc, and that without necessarily undergoing combustion, for the phenomena are not sensibly altered when the experiment is made in an exhausted receiver, or in a vessel filled with an inactive gas, such as nitrogen. It may be said that the transference of carbon from the one pole to the other is simply mechanical, and consists of solid particles detached from the one and carried to the other; but that explanation does not suffice to account for the observed facts, and we are driven irresistibly to the conclusion that there is a partial volatilization of the carbon. The chemist talks of compounds, such as marsh gas and carbonic oxide, as containing so many volumes of carbon vapour combined with so many volumes of the other elements; but I need scarcely say that the combining volume of carbon is deduced, on theoretical grounds, from the [illegible] comparison with analogous cases. [illegible] existing in the free state as a gas [illegible] disputed. So with all other elements, [illegible] compounds, with or without previous [illegible] elements. What we cannot prove [illegible] as the only rational conclusion [illegible] analogy and reasoning.

[illegible] view of the matter. Most liquids [illegible] the solid form. There are, it is [illegible]—of which alcohol may be taken as a [illegible] been frozen; but even in these cases [illegible] the extreme rigour of an Arctic [illegible] which is no doubt an approach to the [illegible] attained by the application of a tem- [illegible] As regards the gaseous condition, the [illegible] requires a little more consideration. [illegible] speaking of *permanent* gases as [illegible] which had been liquified, such as [illegible] chlorine, cyanogen, and so on; [illegible] of water, alcohol, mercury, and [illegible] something different from [illegible] the splendid experimental [illegible] whom the so-called per- [illegible] and nitrogen—have been liqui- [illegible] has long been considered to [illegible] was liquified by Pictet under a [illegible] of 4 tons on the square [illegible] F.; and, in [illegible] reduction of temperature [illegible] gaseous state sufficed to solidify [illegible] the floor, to quote [illegible] small noise of metallic [illegible] call it for the sake of [illegible] after all, and it is only [illegible] that prevents it from pos- [illegible] with which we are familiar [illegible]

[illegible] gases is simply a

[illegible] pressure when it is [illegible] 2,000 feet high.

question of temperature, or, in other words, of molecular motion. In liquids and gases we have, according to the generally accepted kinetic theory, a constant movement of the atoms or molecules, the rate of which differs in the case of each individual gas. It is difficult to define the exact difference between gases and liquids; both possess, to a very large extent, the same functions, and many gases can be converted into liquids by pressure alone, and independently of reduction of temperature. In like manner, if we place a liquid in a confined space and seal it up we can convert it entirely into gas by exposing it to a sufficiently high temperature, provided there is enough space for the expansion of the liquid before it is converted into gas. A cubic inch of water becomes, under ordinary circumstances, a cubic foot of steam or gaseous water; but the water may be converted into gas in a confined space of less than two cubic inches. Many of the experiments on the relations of gases to liquids have been conducted with carbonic anhydride, which, under ordinary temperatures, is liquified under a pressure of about 50 atmospheres. The researches of Andrews, of Belfast, are particularly noteworthy, and are well known to all physical and chemical philosophers. He was the first to observe what is called the "critical point" of a liquifiable gas, a point at which it is difficult to say whether the body exists as gas or liquid; or, rather, we may have both forms existing in the same vessel, but without any distinct line of separation—in fact, they seem to merge into one another. The critical temperature varies with the pressure, and in some gases it is far below zero of Fahrenheit's thermometer. Still, under ordinary circumstances, the physical characters of gases and liquids are sufficiently well marked, besides which we have in the change of state from liquid to gas a large amount of heat rendered latent, and in the contrary action a similar amount of heat becoming sensible.

It is, perhaps, superfluous to dwell further on this interesting subject; but I would like to impress this fact on your minds, that the atoms of matter are the same whatever be the physical condition. In solids, as I have already hinted, the atoms are probably arranged in molecules of symmetrical geometric form. The simplest geometric form is the tetrahedron, in which case only four atoms would be required to form a molecule; but probably there are few molecules so simple, and there is reason to believe that many of them are highly complex, especially the molecules of compound bodies. Crystalline forms, such as we produce by fusion and cooling, by solution and evaporation, or by sublimation, are probably aggregates of the symmetrical molecules; at least we know that some crystals, such as those of Iceland spar, are built up of myriads of smaller crystals of exactly the same form. There are many solids which have two or more distinct forms, which often possess specific properties. Sulphur is one of them; it has at least two distinct crystalline forms, and one that is amorphous. In these various modifications we can readily conceive that the atoms in the molecules are differently arranged, and probably different in number, and that in the amorphous state symmetry is absent, and the atoms or molecules are not grouped into symmetrical forms, but are free and distinct as in liquids, although destitute of motion. Silica affords an excellent illustration of trimorphism. There is the familiar variety known as rock crystal, the form of which is a six-sided prism, and it has a gravity of about 2·6. Another crystalline form, "Tridymite," has a gravity of 2·3, while the ordinary amorphous quartz is only 2·2. All these modifications may be formed by deposition from solutions, but at different temperatures. Sometimes one crystalline form may be transformed into another by the simple application of heat, and the change becomes apparent by some modification of colour or some other property. Thus the scarlet iodide of mercury, when gently warmed, acquires, together with a new crystalline form, a pale yellow colour, which gradually and slowly comes back to the normal tint, which may be more rapidly brought back by friction. Again, the brick-red double iodide of mercury and copper changes to black at the temperature of boiling water, the red colour being restored on the removal of the source of heat. Calcic carbonate has two very distinct crystalline forms, one of which, the rhombohedron, is well known in the mineral form of Iceland spar; the other, a six-sided prism, is seen in arragonite. Now, if a crystal of arragonite is suddenly heated, it falls into a rough powder, which, on examination with a microscope, is seen to consist of minute crystals of Iceland spar.

In liquids and gases we may assume, with some degree of probability, that the atoms are in most cases not grouped into molecules, at least in the case of elementary bodies. In these two forms of matter the atoms are in motion, but the motion is more rapid in gases than in liquids, in the former having what is called a free path, in which they move a considerable distance, compared with their own dimensions, without encountering one another; while in the latter they are constantly coming into collision. The great difference between liquids and gases is that in gases, unless at or near the critical point, the atoms are further apart than in liquids, other circumstances, as of pressure and temperature, being equal. In the case of hydrogen gas, at ordinary temperature and pressure, it has been calculated that the atoms move at the rate of 6,225 feet per second, their size being at most 1-5 millionth of an inch in diameter. The rate of motion, however, is influenced both by temperature and pressure.

The atoms or molecules of gases are inconceivably minute, and the distances between them, although necessarily very far in excess of the dimensions of the atoms or molecules themselves, are also infinitely beyond our powers of perception. In regard to water, we cannot tell the absolute distance of the molecules in steam, but we know this much, that they are twelve times farther apart in every direction than they are in water—a cubic inch of water giving a cubic foot of steam. But gases are different from solids and liquids in being infinitely more readily affected by temperature and pressure. They possess the property of idio-repulsion, which causes their atoms to separate further and further as the pressure is reduced. I am not sure that there is really such a force as idio-repulsion, but it is true, at all events, whatever be the correct explanation of it, that as the pressure decreases the volume increases, and this without any apparent limit. It has been argued that, if matter consists of atoms, it follows that gases have a limit of expansion, beyond which they cannot pass. But it has really nothing to do with the atomic theory, for it is not a question of the infinite divisibility of matter or the reverse, in regard to which there is at the present day no manner of doubt in the minds of chemists and physicists, but simply of the separation of atoms farther and farther apart. In the experiments of Gassiot and Crookes, gases have been reduced to a most extraordinary degree of tenuity, and perfect vacuæ have been obtained—perfect, at least, as regards the particular gases with which the vessels were filled, the last traces being absorbed by chemical agents. For my own part, I cannot conceive of any limit to the distance to which the atoms of a gas may be separated, any more than I can conceive of a limit to space itself. In regard to the atmosphere which surrounds our earth, it probably becomes so attenuated at a distance of about forty miles as to be scarcely appreciable in gravity; but there are really no good grounds for supposing that it is limited to 40, 50, or even 200 miles, or that it does not in some degree fill all space, at least within our solar system. But it is impossible to stop here; if this is so, it follows, almost as a matter of course, that the same space contained at one time—a distance of time that it is as impossible for us to realise as it is for us to form a distinct conception regarding the dimensions of space itself—all the elements which we find on the earth's surface, in the planets, in the comets belonging to our system, and in the sun.

It is well known that if we descend into the earth we soon reach a point at which the temperature is practically constant, affected, to an appreciable extent, neither by the heat of summer nor the cold of winter. This point of constant temperature varies in different parts of the world, but in this country it is about 50 feet from the surface, and is about 47° F. But, if we descend beyond this point by means of a pit or mine, we find a decided increase of temperature the further we descend; and this increment of heat goes on to the greatest depths which have been reached, either by actual descent into the bowels of the earth, or by boring for water to still greater depths. The rate of increment varies at different places from 50 to 100 feet for each degree Fahr. It is, therefore, a natural conclusion that there exists an internal source of heat, which is constantly passing outwards and being dissipated into space. The existence of volcanoes, and of rocks which bear unmistakable evidence of having been in a state of fusion, point to the same conclusion; and it is only a further step to understand that the earth was at a former period in a complete state of fusion, and that it has been gradually cooling ever since. With regard to the question whether there is an internal mass of *fluid* towards the earth's centre, that is a matter which is open to discussion, and which cannot be determined by actual observation. If the increment of heat which we find in descending some hundreds of feet in a pit were continued at the same ratio for a depth equal to only $\frac{1}{30}$ of the earth's radius, or about 80 miles, nearly all bodies with which we are acquainted would be in a state of fusion. As regards volcanoes, there is at least a probability that their occurrence is due in many instances to local causes, and that they are not necessarily connected with an internal igneous mass. In passing, I will only make this one observation in regard to the geology of the earth's crust, that some of the rocks which were formerly considered to be of igneous origin, have, upon further study, been declared to have been deposited from water. Even the granite, which Murchison used to speak of as the backbone of our native land, must, I fear, be relegated to the group of metamorphic rocks, of which it is, however, probably the most ancient.

The earth having been at one period a fluid mass, cooled gradually by radiation; and, after a time, a crust was formed on its surface. But as this crust, itself a very bad conductor of heat, grew colder towards the surface, contraction must have taken place, and irregular fissures produced, giving rise to catastrophes of various kinds, and especially the formation of mountain ranges. Neither can we suppose that the fluid mass was perfectly quiescent: on the contrary, there is every reason to suppose that chemical action was going on, giving rise to the formation of gaseous matter, which found vent in the craters of volcanoes. In course of time the earth became so cold that the aqueous vapour contained in the atmosphere condensed, and a new series of phenomena commenced, one result of which was extensive denudation and the formation of the sedimentary rocks, some of which must have been formed at inconceivably remote periods. The upheavals of the earth's crust, to which I have referred, certainly continued long after the condensation of water, for we find sedimentary rocks high up in the most lofty of our mountain chains; and they occur even at the present time, although in a modified form, and only in certain circumscribed localities.

But, remote as the period of perfect fluidity undoubtedly was, it is a fair and legitimate conjecture, if I may use that word in regard to a matter which scarcely admits of a doubt, that it was preceded by one yet further removed in the dim vista of the immeasurable past. It is true that we are absolutely incapable of contemplating a commencement of the existence of the universe, just as we cannot conceive of the beginning of time, the duration of eternity, or the bounds of space; but if we follow up the thoughts in which we have been indulging, we seem to come unavoidably to a period in which that form of motion which we call heat reigned supreme, in which all matter was gaseous and elementary. How that matter came to be condensed and aggregated into groups, forming a central sun, planets and their satellites, comets, aerolites, and meteoric dust, I shall not attempt to conjecture; but I shall ask you to follow me in a speculation which I trust you will not consider too daring or presumptuous. The cooling effect of radiation on these aggregations of vapours would probably result, in the first place, in the chemical union of the various elements, especially the metals and hydrogen, with oxygen; and as this combination would set free heat formerly latent in the elementary bodies, there would, for a long time, be a period of oscillation between compounds and elements, during which the cooling process would go on with extreme tardiness. Merging imperceptibly into this period of chemical combination would be that of liquefaction of the compounds and the few elements, such as gold and platinum, which possess only slight affinities for the other elements: with a residuum of oxygen and nitrogen gases, and steam more or less mixed with other vapours. Then would follow a period of comparative quiescence; combustion, that is, the combination of the elements, would cease, and enormous contraction in bulk would follow, and the orb would be, to use a vulgar phrase, played out as a source of light to surrounding heavenly bodies, and would soon become covered with a solid crust, which would render it comparatively inoperative as a centre of heat radiation. Then would follow the various phenomena which I attempted to describe as having been experienced in our own little planet; and, if we were to pursue the speculation further still, we should reach a point in the future as dim and distant as the events I have alluded to were in the past, in which sun, earth, and moon, not to speak of the innumerable suns belonging to other systems with which the sky is studded, will be cold and lifeless as the impenetrable ice barriers of the Polar regions. But surely these are not mere speculations; are they not going on before our eyes at the present time? Is not our own earth in the stage of cooling down after having completed its period of active incandescence? and is not the sun at this very moment undergoing the combination of its elements which has gone on for ages and will go on for ages to come? What are the solar prominences but gigantic flames of hydrogen in the act of combination with oxygen, and the photosphere but an almost transparent film of gaseous matter undergoing combustion, while the nucleus is still composed of matter at too high a temperature to admit of chemical combination between its elements? And is not the chromosphere, which gives us the Fraunhofer lines in the solar spectrum, the gaseous or vaporised products of combustion of hydrogen and the various metals which in the body of the sun exist as gases, but condensed to comparatively small bulk by enormous pressure?

The density of the earth is about 5·6, which is about twice that granite, and 1$\frac{2}{3}$ that of trap rock. The weight of the sun, as ompared with water, is only one-fourth that of the earth; and as e constituents, as determined by the spectroscope, are essentially e same, while the effects of gravitation are enormously in excess those observed on the earth's surface, it is a fair inference to nclude that when, in future and far distant ages, the heat gene- ted by the combination of its elementary constituents, and that rived from the changes of state from gas to fluid and from fluid solid, will have been dissipated into space, its bulk will have so r contracted that its gravity will at least equal that of the earth.

Gentlemen, the subject of chemical dissociation, to which I sayed to call your attention this evening, has led me imperceptibly treat of matters which have long been floating in my mind, but which I have not hitherto ventured to give expression; and I ve to crave your indulgence for the exceedingly crude and perfect way in which I have placed these views before you, and so for having failed to notice other theories which have been vanced for the explanation of the phenomena of solar heat and ht. I have to express my great regret, also, that the rule imposed universal custom in learned societies to be observed in the case an opening address has prevented me from exhibiting experi- ntal illustrations. We live in a time of rapid progress in scien- ic research, and talk familiarly of matters of momentous import, ich our fathers never dreamt of. Let us see that we be not ffed up with our knowledge—which, after all, is trifling com- red to what mankind may yet attain to—but ever struggle on, mbly and hopefully, in the earnest desire to learn something of e mysteries of that glorious world in which we are such insigni- ant units. And, above all, let us hope that the knowledge we uire, be it much or little, according to our various capacities d opportunities, may elevate our minds, enable us to regard th equanimity the passing events of a vain and frivolous world, d make us better fitted to lead useful and honourable lives.

I.—*Electric and Photometric Tests of Swan's Incandescent Lamps.*

By ANDREW JAMIESON, C.E., Principal, College of Science and Arts, Glasgow.

[Read to the Society, 16th November, 1881.]

CONSIDERABLE interest was manifested by the members of this Society in the Swan Lamp when Mr. Swan, of Newcastle, read his interesting paper on "Electric Lighting by his Incandescent Lamp" last March.

Many of the members present that evening were very anxious to know, not only how Mr. Swan made his tiny carbon filaments, and how long they would last (and at what candle power), but also what energy (in horse-power) was required to keep them incandescent.

None of these questions were thoroughly answered at the time. Mr Swan had not fully completed the taking out of his patents: neither he nor anyone else had had a sufficiently protracted trial in order to determine the length of life of his lamps, and no one had made any accurate electrical or photometric experiments with them.

Since then Mr Swan has completed his patents, trials of some considerable length have been made with his lamps, and tolerably accurate experiments have been made, not only with Mr. Swan's, but with many of the other well known forms of incandescent lamps which have so quickly sprung into existence. I thought it might be interesting for you to have answers to the above questions, and therefore [illegible] in the form of a short communication.

SWAN'S LAMP, SEE FIG. 1.

The lamp consists of a carbon filament (C), of about the size o thick sewing thread, with thickened ends fitting into split steel tube holders at S S. These holders are similar to an ordinary spli pencil holder, and have small ferrules F, F_2 which, when pushe forward, cause the steel tubes to grip tightly the thickened carbo ends. Above the ferrules the thin steel extends in a semi-cyli drical form, S_1 S_1, as far as F F, which are fine platinum wir soldered to S_1 S_1, and then taken through and fused into the sol

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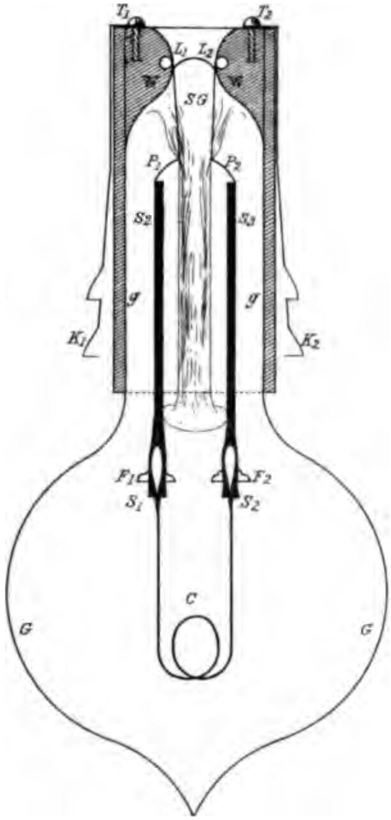
PLATE I.

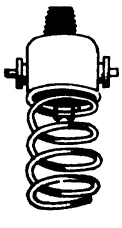
Fig. 1.



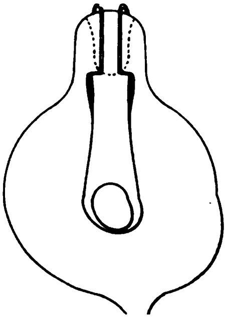
SWAN'S IMPROVED LAMP.

(¾ Full Size.)

HOLDER.



LAMP.



glass at S G, terminating in two small loops. To these loops are soldered thin copper wires, with their free ends twisted round the brass screw terminals, T_1 T_2. The carbon filament, with its holders and terminal platinum wires, is inserted into a glass tube (gg), terminating in a glass globe, G G. Over the end of the glass tube is fitted a neat papier-maché ferrule, with two gilded side contact springs, K_1 K_2, leading from T_1 T_2. Into the end of this ferrule is fixed a hollow wooden plug, in order to make provision for fixing the terminal screws, T_1 T_2.

Sockets or lamp-holders are also provided, into which the lamp (as just described) may be inserted or removed without any more trouble than that of inserting or removing an ordinary candle from a candlestick.

Carbon Filament.—The carbon filament is formed by first subjecting cotton crochet thread to the action of sulphuric acid, mixed with water in the proportion of two of sulphuric acid to one of water. This causes a change to take place in the thread similar in character to that produced by the treatment of bibulous paper with sulphuric acid, according to the well-known process of making vegetable parchment.

The cotton thread, after being immersed in this solution for a sufficient time, is removed therefrom and washed with water until the whole of the acid has been eliminated. It is then dried and carbonized by being placed in a hermetically-sealed metal case and subjected to a high temperature for some time (all air being carefully excluded). The carbon filaments are not unfrequently formed with a loop or double turn, which helps to give a more uniform light in all directions.

Platinum Terminal Wires.—The object for using the expensive metal platinum for terminal wires to the steel holders arises from the fact that the metal platinum comes closest to glass in its coefficient expansion by heat. If copper, iron, or silver were used as the conducting wires through the closed glass end at (S G), the probability is that the greater expansion by heat of those metals would burst or break the glass, or prevent the possibility of retaining a good vacuum inside the globe.

Vacuum in Glass Globe.—The air contained in the glass tube and bulb is carefully removed as far as possible by means of a Sprengel air-pump, &c., and the bulb is hermetically sealed by a blow-pipe at the lower nipple, so that the carbon filament exists in as perfect a vacuum as can be made.

Cause of Incandescence.—The electric current generated, say by a steam-engine revolving the armature of a dynamo machine, is forced from the positive pole thereof along one main leading wire, and crosses to the other or return main lead by forcing its way through the carbon filaments of a number of Swan lamps (whose terminal contact springs, K_1 K_2, are joined to these leads), and thus completing the circuit by returning to the negative pole of the dynamo. The current, in being forced through the fine carbon filaments, meets with a certain amount of resistance; work is done in overcoming this resistance, and its equivalent in heat is generated in the fine carbon thread, which becomes incandescent, giving forth a certain amount of light.

The great object in lighting by incandescent lamps is to keep the resistance of all parts of the electric circuit as low as possible with respect to the resistance of the carbon filaments, so that a maximum of the energy generated by the engine may be concentrated in the lamps, in order to get a maximum of light from them.

With regard to the other questions, I have arranged a system of connections, which I find easy of manipulation (explained to meeting by a large wall diagram). See Fig. II.

The accompanying engraving shows the complete arrangement of the apparatus, and beneath are given the rules followed in making the tests.

Tables I. and II. show the results, and Table III. gives the details of the life of the Swan Lamps at Earnock Colliery.

The details are so fully set forth, that I do not think much further explanation is required. Table III. is interesting, as it shows that long life and prosperity are yet in store for Swan Lamps.* The observations are confined to the lamps only. The lamp to be tested was simply removed from its position in the electric light circuit, and placed in the photometer, the ends of the leads L_1 L_2 taking its place on the main leads, so that its condition while under test was as nearly as possible the same as before.

The photometer was constructed on Rumford's direct shadow principle, which I find answers very well for incandescent lamps up to 15 or 20-candle power. When higher candle powers are obtained, it becomes a matter of personal judgment, and two observers will not give precisely the same results, owing to the

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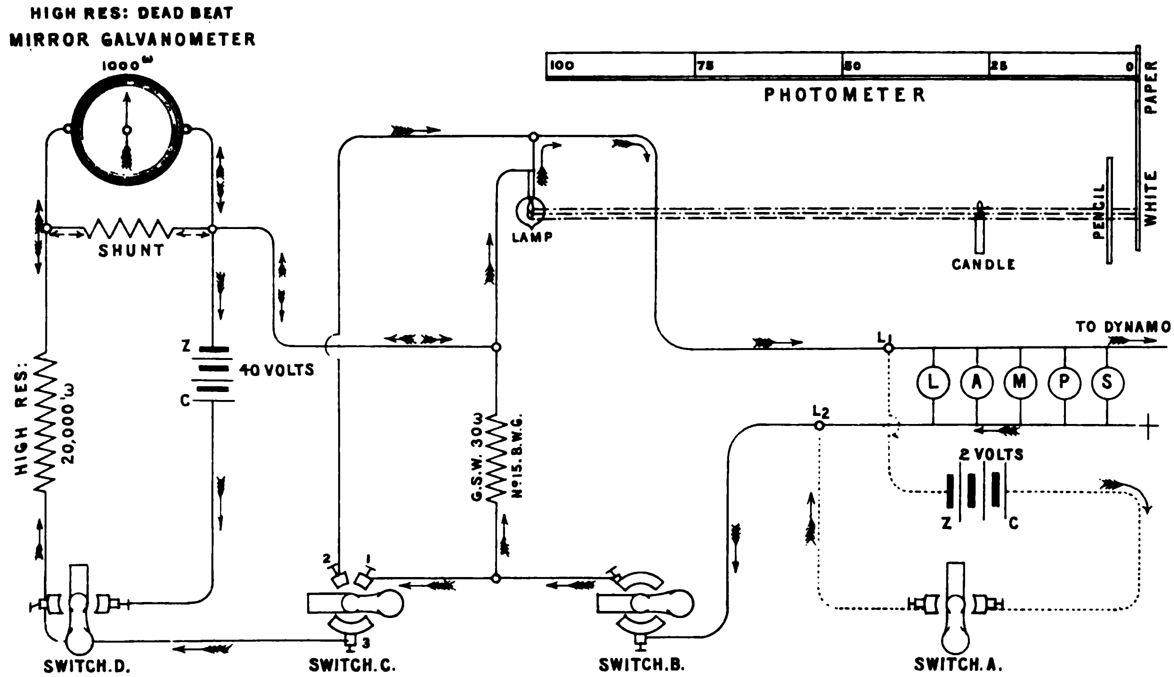
* The Secretary for Swan's Co. informed me the other day, in answer to an inquiry I made, that they had had some of their lamps at work for over 1300 hours without giving way.

Fig. 11.

(Resistance (cold hot), E.M.F. Current, Candles power, H.P. per lamp, Candles per H.P.) USED IN TESTING SWAN'S LAMPS.



great difference in colour of the two shadows—viz., that from the candle and the incandescent lamp.*

While accurately determining the resistance of the German silver wire—which is marked in the engraving above G.S.W., 30^ω, No. 16 B.W.G., which means that it has to be about 30 ohms resistance, and say No. 16 Birmingham wire gauge—by means of a Wheatstone bridge, &c., it is advisable to take the resistance of all the lamps (cold) that are afterwards to be tested by the special method, both cold and hot, in order to prove the accuracy of the connections and galvanometer in the special test.

The principle employed in determining the resistance of the lamps, both cold and hot, by the special method, is that of comparing the deflections obtained on a high resistance galvanometer —placed in a very high resistance circuit—joined up as a shunt, first to the known and the accurately determined 30^ω of German silver wire, and, secondly, to the lamp under test. Then,

For Res. cold $D_1 : D_2 :: 30^\omega : R$.

For Res. hot $D_3 : D_4 :: 30^\omega : r$.

The electromotive force, or difference of potential between the terminals of the lamps when hot, is found by comparing the deflection obtained from the same, with that of a battery of known electromotive force.

$$\therefore D_5 : D_4 :: 40^{\text{volts}} : E.$$

The candle-power is always obtained at the same instant as the resistance hot and the electromotive force; and three or four minutes suffices for getting all the necessary deflections from one lamp for working out the details as given in Tables I. and II., when once the connections have been satisfactorily joined up, and found correct.

RULES FOR TAKING TESTS, &c.

See Fig. 1.

(*Resistance cold*)—Free dynamo leads L_1 L_2. Close switches A, B, C (1—3); take deflection D_1.—Close switches A, B, C (2—3); take deflection D_2.

$$\therefore D_1 : D_2 :: 30^\omega : R.$$

$$\therefore \frac{D_2 \times 30}{D_1} = R \text{ (Resistance cold) } ^\omega.$$

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* The photometer used by Dr. Wallace was the same as he uses for testing the Glasgow gas—viz., a 100-inch bar with two candles (Bunsen's, made by Sugg of London).

(*Resistance hot*)—Free switch A; join on dynamo leads L_1 L_2. Adjust unt; find D_3 and D_4 by same plan as D_1 and D_2.

$$\therefore D_3 : D_4 :: 30\omega : r \quad \therefore \frac{D_4 \times 30}{D_3} = r \text{ (Res. hot) } \omega.$$

(*Electromotive Force*)—Free switches A, B, C; close switch D; take lelection D_5.

$$\therefore D_5 : D_4 :: 40 : E \therefore \frac{D_4 \times 40}{D_5} = E \text{ (E.M.F.) Volts.}$$

(*Current per lamp, hot*)—(Ampères) $= \dfrac{E}{r}$

(*Candle-power*) = K (from comparing with standard candle).

(*Horse-power per lamp*)— $\dfrac{E \times C}{746}$

(*Candles per horse-power*)— $\dfrac{K \times 746}{E \times C}$

(*Heat—Units per candle in gramme degrees*)— $\dfrac{E \times C \times \cdot 24}{K}$

TABLE I.

Tests taken of Swan's Lamp, No. 1, at College of Science and Arts. March, 1882.

No. of Expt.	Res. in ohms (R — r).	E. M. F. in Volts (E).	Current in Ampères (C).	Units of Work (E × C).	Candle Power Observed (K).
1	65·5	·4	...	...	...
2	63·	1·7	...	...	...
3	56·	4·25	...	...	...
4	50·8	6·4	...	...	...
5	49·5	8·5	...	...	...
6	49·3	7·4	...	...	...
7	47·5	9·3	·19	...	...
8	45·2	11·9	...	...	...
9	44·1	13·3	·3	...	Dull red.
10	42·1	15·	...	...	...
11	41·2	17·8	·43	...	...
12	39·7	20·3	·51	...	...
13	38·6	22·5	·59	...	Very bright red.
14	38·5	23·6	·61	...	...
15	37·5	25·7	·69	17·6	·5 (S)
16	35·7	29·	·81	...	...
17	35·	32·	·91	29·2	2·0 (S)
18	34·	37·3	1·1	40·9	5·4 (W)
19	32·5	39·	1·2	46·8	7·5 (S)
20	33·3	42·2	1·27	53·5	12·5 (W)
21	32·	46·5	1·45	67·7	22·3 (W)
22	31·8	46·9	1·47	69·2	23·7 (W)
23	31·4	47·1	1·5	70·7	23· (S)
24	31·1	49·4	1·58	78·4	32·6 (W)
25	30·9	53·1	1·71	91·	55· (W)
26	...	...	...	...	...

Candles with (W) after them mean that they were taken by Dr. Wall with Bunsen's Photometer, and those with (S) by myself, with Sha Method (Rumford's).

The above Table is substituted for that shown at lecture, as it is exact.

TABLE II.

at Sir William Thomson's Laboratory with his Potential Galvanometer and Ampère-meter, on 13th Feb., 1882.

r used was constructed on Rumford's plan. See Fig. 2 for connections.

Swan's Lamps (old ones).

old ge	Res. Hot Ohms. (r)	E. M. F. Volts. (E)	Current Ampères. (C)	Candle Power. (K)	Horse-power per Lamp. $\left(\frac{E \times C}{746}\right)$	Number of Candles per Horse-power. $\left(\frac{K \times 746}{E \times C}\right)$	Heat units in Gramme Degrees per Candle. $\left(\frac{E \times C \times \cdot 24}{K}\right)$
	32·5	39·	1·2	7·5	·0627	120	
	33·9	42·	1·24	9·	·0698	129	
	32·5	39·	1·2	8·	·0627	128	
	30·5	39·7	1·3	9·	·0692	130	
	35·7	41·	1·15	9·	·0632	143	
8	33·0	40·14	1·22	8·5	·0655	130	1·38
	31·4	47·1	1·5	23·	·0947	243	
	33·6	47·	1·4	20·	·0882	227	
	30·4	47·4	1·56	23·	·0991	232	
	30·0	48·	1·6	21·	·1030	200	
	34·8	48·7	1·4	21·	·0914	225	
8	32·	47·6	1·49	21·6	·0953	225	0·79
	29·9	53·8	1·8	40·	·130	308	
	32·0	51·2	1·6	31·	·110	282	
	30·0	51·	1·7	34·	·116	293	
	29·3	51·2	1·75	34·	·120	283	
	34·3	51·	1·5	31·	·103	302	
8	31·1	51·64	1·67	34·	·116	293	0·61

Table has been substituted for the one shown at lecture, as it is more

TABLE III.

December 9th, 1881, 11 a.m.—Life of Swan's Incandescent Lamps at Earnock Colliery. Date of installation, August 11th, 1881. Number of hours the lamps are lit daily is 10½, *except Sundays and Saturday afternoons, or sixty hours per week.*

No. of lamp.	Date put in.	Date of breaking.	Cause of renewal.	Number of hours lighted.	Lamps now in use. Hours Lighted.
1^1	Aug. 11th	...	Still lighted	1040	1040
2^1	Ditto.	Aug. 25th	Carbon broke	112	
2^2	Aug. 25th	Sept. 10th	Ditto	130	
2^3	Sept. 10th	Oct. 5th	Ditto	210	
2^4	Oct. 5th	...	Still lighted	560	560
3^1	Aug. 11th	...	Still lighted	1040	1040
4^1	Aug. 11th	Sept. 7th	Carbon broke	230‡	
4^2	Sept. 7th	...	Still lighted	800	800
5^1	Aug. 11th	Sept. 7th	Carbon gave way	222‡	
5^2	Sept. 7th	Sept. 8th	Ditto	10	
5^3	Sept. 8th	Sept. 13th	Ditto	50	
5^4	Sept. 13th	Sept. 22nd	Ditto	360†	
5^5	Sept. 23rd	Sept. 26th	Ditto	20	
5^6	Sept. 26th	...	Still lighted	640	640
6^1	Aug. 11th	Sept. 17th	Carbon broke	312	
6^2	Sept. 17th	Sept. 21st	Ditto	30	
6^3	Sept. 21st	..	Still lighted	680	680
7^1	Aug. 11th	...	Still lighted	1040	1040
8^1	Aug. 11th	Oct. 11th	Carbon broke	520	
8^2	Oct. 11th	...	Still lighted	510	510
9^1	Aug. 11th	Sept. 13th*	...	...	
9^2	Sept. 13th	...	Still lighted	750	510

Lamps are numbered from the bottom of shaft inwards 1^1 to 17^1. Renewals are marked 5^2, 5^3, 5^4, 5^5, and so on.

‡ On September 7th, from some unknown cause, five lamps gave way—viz., 5^1, 11^1, 12^1, 13^1, 14^1—marked thus ‡.

* No. 9^1 lamp put into No. 5^4, with a previous life from August 11th—280 hours. No. 5 is next to the bottom of the shaft, where the men could switch it off and on with ease, which may possibly account for frequent renewals. Since the switch was removed the lamp has not required renewal.

† Shifted to replace No. 5^3, and therefore called No. 5^4.

N.B.—Lamps Nos. 1^1 and 3^1 were measured by Mr. Gilchrist and self in the cabin at foot of shaft, and gave 6·25 and 6·5 candles respectively. The others in the mine were apparently about the same power. I got the above from Mr. Gilchrist, manager of Earnock Colliery, who reported it to the Mining Institute of Scotland.

TABLE III.—Continued.

Date put in.	Date of breaking.	Cause of renewal.	Number of hours lighted.	Lamps now in use. Hours Lighted.
Aug. 11th	Aug. 23rd	Carbon broke	130	
Aug. 25th	Oct. 19th	Ditto	470	
Oct. 20th	.	Still lighted	430	430
Aug. 11th	Sept. 7th	Carbon broke	230	
Sept. 7th	.	Still lighted	800	800
Aug. 11th	Sept. 7th	Carbon broke	230‡	
Sept. 7th	Oct. 10th	Renewed owing to giving bad light	280	
Oct. 10th	Oct. 24th	Carbon broke	130	
Oct. 24th	...	Still lighted	400	400
Aug. 11th	Sept. 7th	Carbon broke	230‡	
Sept. 7th	Oct. 11th	Ditto	290	
Oct. 12th	...	Still lighted	500	500
Aug. 11th	Sept. 7th	Carbon broke	230‡	
Sept. 7th	...	Still lighted	800	800
Aug. 11th	..	Still lighted	1040	1040
Aug. 11th	Sept. 26th	Broke by accident	382‡	
Sept. 29th	Nov. 26th	Carbon broke	500	
Nov. 26th	...	Still lighted	110	110
Sept. 30th	...	Still lighted	600	600

IN MEMORIAM.—DAVID FOULIS.

[Read before the Society, 16th November, 1881.]

eems fitting that there should be a permanent record of the nd life-work of David Foulis, a Member of this Society, whose death we now deplore, and I have therefore attempted in a sentences to state the chief facts of his short, and, in many cts, remarkable career.

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n September 7th, from some unknown cause, five lamps gave way 5‡, 11‡, 12‡, 13‡, 14‡—marked thus ‡.

David Foulis was born on the 13th of November, 1846. After the usual preliminary education, he began the study of medicine at the University of Glasgow in 1862. In 1864 he was induced to go to India as a tea planter, and his medical studies were interrupted, so far as academical teaching went, till 1871, when he returned and resumed attendance at classes; but it was characteristic of the bent of his mind that even in India he never relinquished the desire to study medicine, and whilst there took every opportunity of studying cholera and the common diseases occurring in that climate. In 1873 he graduated as Bachelor of Medicine at the University of Glasgow with highest commendation, having spent the summer session of that year at the University of Edinburgh. The following year, 1874, was spent at the medical schools of Leipsig and Vienna, where he devoted special attention to pathology and surgery. In 1875 he became house physician in the wards of the Royal Infirmary, under the care of Dr. Gairdner, and house-surgeon in the Western Infirmary under Dr. George Buchanan, and he was then appointed Pathologist to the Royal Infirmary, and curator of its pathological museum. Shortly afterwards he became lecturer on pathology in the Royal Infirmary school of medicine, and he was soon elected one of the dispensary surgeons of that institution.

Whilst acting in these various capacities his mind was constantly directed towards the advancement of professional knowledge, more especially in the departments of pathology and surgery and from time to time he made substantial contributions to medical science. I find he wrote no fewer than 50 separate papers for various Journals.

He took an active interest in the Clinical and Pathological Society of Glasgow, as is shown by the following extract from its Minutes, which has been sent to me by its Secretary, Dr. Finlayson :—"Dr. David Foulis made his first communication to the Society in January, 1875, and was elected a Member in the following month. This was before he became Pathologist to the Royal Infirmary.

"Since then he made many contributions to the *Transactions* of the Society, numbering about 40 in his own name. Not a few of these were communications of great value and importance, and amongst them may be mentioned his case of Extirpation of the Larynx, which was first brought under the notice of the profession at this Society on November 13th, 1877, when it was

d specimens for various members of the profession both here
t a distance; and, besides all this, very few specimens of
st were shown by members connected with the Royal Infir
which were not so far prepared for exhibition by his previous
nation." Such is the testimony of the society in which he
. most active interest.

Pathologist to the Royal Infirmary, he was indefatigable in
ischarge of his arduous duties. In particular, he devoted
time and skill to enriching its museum with hundreds of
ogical preparations, which will be of use in the training of
generations of medical men. A clear and precise speaker,
ame an admirable teacher, and he held the attention of his
its not merely by the charm of his style, but by the subtle
nce exercised by a teacher who speaks with authority of
he himself has seen or investigated.

ly devoting himself to the special study of diseases of the
, Dr. Foulis made many contributions to the surgery of the
, and more especially he twice successfully removed the entire
, and on two occasions he removed only a portion of it
was also adapted to the first of these cases an artificial
gement (constructed from a [illegible]
member of this Society), consisting of a [illegible] by
voice could still be produced. These [illegible] operations
ted great attention both at home and abroad, and placed him
in the first rank as an operator on the organs of [illegible]
an operator, he combined boldness [illegible]
e object in view, he had the [illegible] of [illegible]
ulative dexterity which were [illegible]
ologist, he was profoundly [illegible]
ms of his science, and [illegible]
the chief foundations of modern [illegible]
was ever earnest in the [illegible] of [illegible]
f facts bearing on the subject in hand. [illegible]
kable as a clear and accurate [illegible]

strongly developed of seeing things as they are, and not as surrounded by the glamour of preconceived theory and opinion. To him accuracy of statement and clearness of reasoning were of the highest importance, and there can be no doubt that to these qualities must be attributed much of the professional success he obtained during a short lifetime.

Strange that a life so valuable to humanity should be cut off even before its prime! In the midst of his work, and whilst engaged in his professional duties, he was attacked by diphtheria, infection having been acquired during the performance of tracheotomy on two children who suffered from this terrible disease.

Dr. Foulis had the first feeling of illness on Sunday, 24th October, but persisted in his work, making a post-mortem examination even on the afternoon of that day. On Monday evening he was so unwell as to require to take to bed, and, though no better on Tuesday, he insisted on doing his work, and on Wednesday he got out of bed to pay an urgent visit. His throat on Tuesday was ulcerated, and on Wednesday became distinctly diphtheritic. From Wednesday evening the illness was pronounced, but not seemingly very severe till Sunday morning, from which time he quickly sank, and died on Monday, 31st October, 1881, about five p.m., before completing his 35th year.

Such is a brief record of the life of David Foulis. Of his private character it may be said that modesty, self-possession, and an affectionate and considerate nature, won for him the esteem of a wide circle of friends. It would be out of place to write one word more on this aspect of his life. His memory is enshrined in the hearts of those who loved him most because they knew him best, and all we can offer to them is our deepest sympathy and this feeble testimony to his honourable and useful life. By his early removal the members of his own profession, not merely in Glasgow but throughout the kingdom, feel that they have suffered a great loss. Had he lived, no one can tell what benefits to humanity might have been conferred by a mind so keen and enthusiastic and a hand so dexterous; but even in his short life he did much, and he has left a bright example of what devotion to duty, untiring perseverance, and noble qualities of personal character may be able to accomplish.*

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* Written by John G. M'Kendrick, Professor of Physiology in the University of Glasgow, and Secretary of the Society.

II.—*The Decade 1871-80 in Glasgow—A Sanitary Retrospect.*

By JAMES B. RUSSELL, B.A., M.D., Medical Officer of Health, Glasgow.

[Read to the Society on 30th November, 1881.]

THE facts ascertained at a census of the population have a threefold importance. They determine the statistics of the inhabitants at the date of the census; they furnish data for the revision of the estimates made from year to year during the ten years which have elapsed since the census preceding; and they furnish data for the estimates which will fall to be made from year to year during the ten years which will elapse before the next enumeration. The retrospective study of the census data is most important, because their prospective application is in reality nothing more than the assumption that the population will, in the future, advance upon the lines it has followed in the past. The latent motive of my present paper is not merely to communicate certain interesting information regarding the social and sanitary statistics of the City of Glasgow, derived from a study of the recent census; but to show you that this assumption has, as regards the decade 1871-80 in Glasgow, proved to be entirely wrong, and that the data of a decennial census is utterly insufficient as a basis for a correct estimate of the vital movements of a great commercial community. It would be just as reasonable to pretend to anticipate the weather of next year from an average deduced from observations taken at the beginning and end of last year as to presume that you can compute the rise and course of [illegible] which arise in a community living by trade and commerce, from its condition at two points separated by such a [illegible] interval as ten years. The facts now to be communicated are valuable in themselves, but they will certainly also shape themselves in your minds into an argument in support of this inference, and I shall therefore make no further specific reference to it.

The cardinal fact, to the determination of which the enumeration of the population at each census must be applied, is the rate of growth of the population between one census and another.

In order to obtain a trustworthy estimate of the growth of a population, we must first determine accurately the area of the earth's surface upon which they live. This area must always be the same. The history of the development of Glasgow is peculiarly difficult to trace correctly, because of the confusion of boundaries. The area which is designated Glasgow is not always the same. There is Parliamentary Glasgow and Burghal Glasgow, and there are the Suburbs of Glasgow. The Burghal Glasgow of one census is not that of another, and the Registration Burgh of Glasgow has not always embraced the whole actual Burgh. The Suburbs of one census are not the Suburbs of another, partly from the inclusion within Glasgow proper of districts previously treated as Suburbs, and partly from districts further afield being, by the compilers of successive enumerations, embraced within what they please to call Suburbs. These puzzling variations have been discussed and explained by the present City Chamberlain in his Report upon the Statistics of Glasgow for 1868, pp. 43-45.

The boundary of Glasgow which has been longest without change is the Parliamentary, fixed by the Reform Act of 1832, and to this day absolutely unaltered. In 1846 the Municipal boundary was made co-extensive with the Parliamentary; but, by the Municipal Extension Acts of 1872 and 1878, about 1,048 acres, with the population thereon, have been added to the Municipality, so that to that extent the Municipal goes beyond the Parliamentary area, and embraces 6,111 acres. It follows, therefore, that to trace the development of the population within either Parliamentary or Municipal Glasgow, as defined in 1881, it would be necessary to determine at each Government Census, back to the first in 1801, the population living on the present superficies of those areas—an almost impossible task. The Scotch Registration Act came into force on 1st January, 1855, and the Parliamentary boundary was the limit of the Registration area of Glasgow until 1st January, 1875, when it was entirely changed, both by a new subdivision of the area within the City (including, for the first time, for Registration purposes, the portions added to the Municipality in 1872), and also by extension, so as to embrace, under the designation "Landward," certain suburban districts—thus still further complicating and adding to the risks of statistical fallacies in any attempt to trace the development of the community.

In 1875, when this rearrangement of the Registration subdivisions of Glasgow was made, the Registrar-General, with the materials to which he alone has access, went back upon the census records of 1861 and 1871, and determined the population within the same boundaries, so that we have the following succession of strictly comparable populations :—

		Burghal.*		Landward.		Total.
1861,	...	404,314	...	5,607	...	409,921
1871,	...	491,846	...	16,474	...	508,320
1881,	...	511,520	...	39,121	...	550,641

The "Landward" portions of the Registration area of Glasgow embrace so much of the present "suburbs" of Glasgow as are known by the designations of the Burghs of Kinning Park and Govanhill, the two Burghs of Pollokshields, the districts of Strathbungo and Polmadie, and an extensive area stretching eastwards along Cumbernauld Road, and north of Springburn. This obviously leaves out large and populous suburban areas, but it gives us a strictly correct basis of comparison so far as it goes, and shows the development of what the Registrar-General has constituted the Registration area of Glasgow.

		Burghal Increase.			Landward Increase.			Total Increase.	
		No.	Per cent.		No.	Per cent.		No.	Per cent.
1861-71,	...	87,532	21·66	...	10,867	193·8	...	98,399	24·00
1871-81,	...	19,674	4·00	...	22,647	137·4	...	42,321	8·30

These figures speak for themselves. They show that, even including so much of the suburbs of Glasgow as are comprised within the Registration area, the development during last decade is only one-third of the development during the decade preceding, while within the Burgh proper it did not amount to one-fifth.

But we may obtain a sufficiently correct and comparable observation of the development of Glasgow, with all the more important suburbs. At p. 69 of the City Chamberlain's Report for 1880 there is a statement of the increase of the "city and suburbs" between 1871 and 1881. At p. 89 of his Report on the Census of 1871 we find a statement of the increase of "Glasgow and its suburbs" between 1861 and 1871; but Rutherglen, Pollokshaws,

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* It must be carefully noted that the population here *called* Burghal in 1861 and 1871 is not the *real* Burghal population of those years, but the population on the area which is Burghal in 1881.

Cathcart, Crosshill, Mount Florida, Langside, and Crossmyloof are included in the former statement and not in the latter. It is scarcely justifiable to include either Rutherglen or Pollokshaws. Therefore, excluding these from 1881, and adding the Registration District of Cathcart, which embraces Crosshill, Mount Florida, &c., to 1861 and 1871, we get the following view of the recent development of everything that can fairly be called Glasgow and its suburbs :—

	Population.	Increase.	Rate of Increase.
1861,	450,174	—	—
1871,	573,381	123,207	27·36
1881,	681,222	107,841	18·80

These figures show that Glasgow, as a community, throwing aside all artificial subdivisions, diminished its growth during the last, as compared with the former decade, by a third. If, now, we divide this community into two parts—one Burghal, in the sense described above—viz., the population on the Burghal area of 1881, and the other Suburban—we get an interesting and important observation of the rate of development of these populations living on areas which are exactly the same at each enumeration, the one being urban and centric, the other suburban and eccentric.

	Burghal.	Suburban.	Total.
1861,	404,314	45,860	450,174
1871,	491,846	81,535	573,381
1881,	511,520	169,702	681,222
Increase—			
1861-71,	87,532	35,675	123,207
1871-81,	19,674	88,167	107,841
	or 21·65 per cent.	77·79 per cent.	27·36 per cent.
	4·00 do.	108·13 do.	18·80 do.

These figures, looked at as they stand, seem to show that the falling-off in the rate of development of Glasgow, as defined by the municipal boundary, arose, at anyrate in great part, from the emigration of her population to the suburbs. The suburban gain was 88,167 in the ten years 1871-81, the urban only 19,674. Still the rate of growth of the *entire community* was 8½ per cent. less in the last decade than in the preceding; and if the suburbs added 108 per cent. to their population in the face of the adversity of the times, we can hardly set limits to their possible increase had the times been prosperous.

We find, then, that instead of growing at the rate of 21·6 per cent. Municipal Glasgow only grew 4 per cent. between 1871 and 1881. How did the other large towns in the kingdom fare? The practical importance of the answer to this question will be best shown by dealing not with the comparative growth in the two decennial periods 1861-71 and 1871-81, but with the estimates, based upon these data, of the population, as they were in use up to the last census, as compared with the actual population ascertained at the census. Calculating the difference as a percentage upon the true population, we find that in the Scotch towns the true population was—in Greenock, fully 13 per cent. *less;* in Glasgow, 17½ per cent. *less;* in Dundee, fully 11 per cent. *less:* in Edinburgh, 2 per cent. *less;* while in Paisley it was 12 per cent. *more;* in Perth, 10½ per cent. *more;* in Leith, nearly 3 per cent. *more;* and in Aberdeen alone practically the same. Without going into the same detail with regard to the twenty large English towns, it may be said that in twelve the true population was found to be *less* by amounts ranging from 10½ per cent. in the case of Bradford and 9½ per cent. in the case of Sheffield to 1½ per cent. in the case of Plymouth; while in five it was *more* by much smaller amounts, including London, with the largest excess above the estimated population—fully 3 per cent. In the case of the remaining three towns—viz., Salford, Oldham, and Nottingham—the divergence had become so apparent in the course of the ten years that the English Registrar-General had been persuaded by local representations to modify his estimates from local information, but with no better result, for the two former towns were found to have populations respectively 9 and nearly 7 per cent. *less,* and the latter nearly 6 per cent. *more* than the estimate.

These figures prove incontestably that the rate of growth of towns is so variable that the rate of one decade affords no presumption of the rate of another. As a matter of fact, the majority of the English towns, and the most important of the Scotch have, during the decade 1871-80, fallen far short of their development in the decade 1861-70. The following are the rates of increase of the eight Scotch towns in the last two decades, arranged in the order of the decade 1871-80:—

	1871-80.	1861-70.
Leith, ...	31·73 ...	28·87
Aberdeen, ...	19·13 ...	19·32
Dundee, ...	18·00 ...	31·70
Edinburgh, ...	15·48 ...	17·51
Paisley, ...	15·30 ...	1·75
Greenock, ...	15·22 ...	36·22
Perth, ...	12·79 ...	1·10
Glasgow, ...	4·00 ...	21·64

Glasgow occupies the unique position in the whole kingdom of having the smallest increase. The lowest rates of urban growth in the country, excepting Glasgow, are those of Norwich and Plymouth, and these are more than twice as great as that of Glasgow, and [illegible] less than one-fifth of the growth of the [illegible] the case of Glasgow, their rates are in one case [illegible] almost as great. The case of Manchester [illegible] as while in 1861-70 it increased [illegible] it actually decreased 2·8 per cent. [illegible] justly remarks — "With this must [illegible] the fact that the closely-adjoining [illegible] of Salford showed an increase of no less than 41·2 per cent [illegible] towns together, there was an increase of [illegible]

There are [illegible] facts which it is important to mention in [illegible] that both Scotland and England have [illegible] at a rate exceeding that [illegible] in the former since 1821-30.* [illegible] The other fact is that taking the [illegible] it is found that the natural [illegible] the surplus of births over deaths [illegible] the actual increase of population [illegible] more clearly expressed than in [illegible] Registrar-General:§ — "The difference [illegible] and the total number of deaths [illegible] natural increment of the people [illegible] an increase of 15·68 per cent. upon [illegible] period, and as the actual [illegible] was 14·34 per cent. the [illegible] movements of the population [illegible] resulted in a loss of no more [illegible] In the two previous [illegible]

[illegible] different. The actual increase [illegible] as we have seen, 4 per cent. The [illegible] the same limits during the [illegible] of fully 12 per cent.

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* Census of England and Wales, [illegible] Preliminary Report, p. 8.

† Census of Scotland, [illegible] Preliminary Tables, p. 4.

‡ Census of England and Wales, [illegible] Preliminary Report, p. 3.

§ Ibid., p. 3.

Therefore there has been a balance of loss by emigration beyond those limits of 8 per cent.

The next important fact which the census furnishes is the average number of inhabitants per occupied house. In my opinion, provided we can from year to year ascertain the number of houses in which the population lives, this is more important than the average rate of growth. Except by actual enumeration, these two facts furnish the only data for estimating the population in the years intervening between one census and another.

Unfortunately, the data for the determination of the inmates per house have, until last census, been haunted and deranged by the importation into Scotch enumeration of English notions of the definition of a house. Still, from independent local efforts, trustworthy information was, after 1811, obtained. In the following table I have collected information as correctly as possible from the sources indicated on this and other matters :—

Authority.		Per House (with Institutions and Harbour).	Per House (without Institutions and Harbour).	Rooms per House.	Inmates per Room.	Per cent. Unoccupied Houses.
I.	1801	3·816 ?	...	...	...	$5\frac{1}{2}$
I.	1811	5·742 ?	...	...	..	$3\frac{4}{5}$
I.	1819	4·734	4·681	2·283	2·050	4
II.	1821	4·646	...	...	... *	$5\frac{7}{10}$
III.	1831	4·866	...	...	...	4
IV.	1841	5·234	5·050†	...	...	$4\frac{1}{5}$
	1851	5·222	5·050	...	...	$2\frac{4}{10}$
	1861	4·787	4·720	2·292‡	2·088‡	$4\frac{6}{10}$
	1871	4·861	4·793	2·307‡	2·104‡	2
	1881	4·801	4·738 §	2·342 ‖	2·054 ‖	$10\frac{7}{10}$

I.—Enumeration of the Inhabitants of the City of Glasgow. Dr. Cleland, 1820, pp. 5 and 6.

II.—Enumeration of the Inhabitants of Scotland, &c. Dr. Cleland, 1823, p. 32.

III.—Enumeration of the Inhabitants of the City of Glasgow and County of Lanark for the Government Census of 1831, &c. Dr. Cleland. 1832, p. 209.

IV.—Watt's, Strang's, and Watson's respective Census Reports.

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* "For every apartment there are two persons to occupy it."—Note by Dr. Cleland.

† 5·15 for City and Suburbs.

‡ Parliamentary Burgh.

‖ Municipality.

§ The average over the whole Registration Area is 4·76.

Beginning with Dr. Cleland's elaborate and careful special census in 1819, we have a succession of trustworthy data. These show that the average number of inmates per occupied house has considerable limits of variation. Excluding Institutions and Harbour, the highest was 5·05 in 1841 and 1851, the lowest 4·68 in 1819—a range of ·37. The high average in those two years is not explained by Dr. Strang. Probably it arose from the eccentric growth of the city, comprising the larger class of houses, not being yet projected beyond the bounds. It is at anyrate remarkable that the average per house in the *suburban parts of the present Registration area* is 5·082. Comparing the condition of the city as to house accommodation, as disclosed by the recent census, with its condition at those preceding, we observe that the number of persons to each house is lower than in 1871, but not so low as in 1861; that the average size of the houses is slightly more commodious now than in 1819, as regards the number of rooms, and relatively to the number of inmates per room about the same. Probably the fact which is at the bottom of this increase of house room is the last which this table proves with reference to accommodation—that the number of unoccupied houses is about 11 per cent. of the whole, nearly twice the proportion of which there is any record at any period, the next highest being $5\frac{7}{10}$ in 1821. That this is the explanation seems confirmed by the circumstance that in 1871, when the proportion of empty houses was only 2 per cent.—the lowest on record—the number of inmates per house was higher than at any census since 1851; and the number of inmates per room was the highest on record. Apparently the most general expression of the meaning of these figures is, that in times of great prosperity and rapid growth there is a tendency to overcrowding of the house accommodation, and that one of the effects of the opposite condition of city life is not only to diminish the population by reducing the householders, but to reduce the size of the families by driving out lodgers, and leading to the emigration of adults in search of employment. Therefore, from a sanitary aspect, the conditions of health of the remaining population are improved by the thinning of the inhabitants, and the consequent increase of air space.

We are, indeed, in possession of exact figures as to the comparative housing of the population at different points in the last decade, so far as this can be estimated by the number of apartments per house. The following statement shows the classification of the total houses (occupied and unoccupied) in the city in 1873 (the earliest year for which I have the information) and in 1880 :—

	1 Apt.	2 Apts.	3 Apts.	4 Apts.	5 Apts. & up.	Total.
1873, ...	35,037	45,828	14,090	5,521	6,361	10,6837
1880, ...	35,843	52,693	17,746	6,623	6,223	119,128
Difference, ...	+806 or 2·3°/o	+6,865 or 15°/o	+3,656 or 26°/o	+1,102 or 20°/o	−130 or 2·1°/o	+12,291
Percentage, 1873,	32·80	42·90	13·19	5·16	5·95	
Do., 1880,	30·08	44·23	14·88	5·56	5·22	
Difference, ...	−2·72	+1·33	+6·69	+0·40	−0·73	

So that Glasgow, while still and increasingly a city of small houses (no less than 75·7 per cent. being houses of 1 and 2 apartments in 1880, against 74·3 per cent. in 1873), has a smaller proportion of single apartment houses and a larger proportion of houses of 2 and 3 apartments than in 1873. The number of houses of 5 apartments and upwards bears such a small proportion to the whole that, although they are now absolutely less by fully 2 per cent. than in 1873, the average shows an improvement in this important matter of house room. The great central difference between the forecast of the decade and the retrospect, involved within which and surrounding which are many subordinate differences, is this—that in place of adding to our population at the rate of nearly 22 per cent., as we did in the decade preceding, we have added only 4 per cent. So expressed, this is like the annual balance of a merchant's books. The balance shows a profit or a loss of so much on the year, but the few figures which give the amount on one side or the other represent the outcome of a multitude of transactions spread over the year. Had the balance been taken month by month one would have shown a profit, another a loss, or perhaps an increasing profit or an increasing loss. As the growth or decline of a city is in its ultimate nature a vital process, a truer analogy will be found in some essentially vital phenomenon, such as the growth of a child into the adult. This is measured by stature and weight; but when we say the average gain in weight or in height in a year is so much, we express the process of nature in the form of an arithmetical fiction. The process of nature is gradual always in health, subject to the abnormal interferences of disease, sufficient or insufficient nutrition,

&c., &c. No acute angle in reality marks the passage from one period to another. So it undoubtedly is with a city. The method adopted by the Registrar-General is to assume that on the 1st January, 1871, Glasgow suddenly ceased to develop at the rate of 2·165 ($\frac{21\cdot65}{10}$) and began to develop at the rate of ·4 ($\frac{4}{10}$) annually. He will therefore sweep aside all the calculations as to death, birth, and marriage rates, which he has published on the assumption that the rate of growth continued into last decade at 2·165 per annum, and substitute calculations based on the assumption that the rate suddenly became ·4. But more than this, he will, until next Census is taken, calculate all his rates upon the assumption that the slow rate of growth continues. Both of these assumptions are alike contrary to the natural probabilities of the case. What I now propose to do is to endeavour to raise those probabilities to the position of certainties, by collecting such facts as are accessible in proof of the gradual nature of the declension of our rate of growth. Some of these facts are simple matters of local and national history. The decade began in the heyday of commercial prosperity. It led us year by year into the depths of unprecedented depression, and left us in sight of a revival of trade. The failure of the City of Glasgow Bank in the autumn of 1878 added local intensity to a condition which previously we had simply shared with the country generally. The winter of 1878-79 was probably the gloomiest which the City had ever seen, and fraught with more anxiety to its rulers. A gigantic organization for the relief of the unemployed was in operation, and renewed on a smaller scale in the winter ensuing. In 1878-79 nearly 14,000 applications for relief were received from persons whose dependants numbered 26,500 souls. Above £26,000 were expended in food and wages for test-work. Other facts, which give us evidences of the gradual declension of the City, are capable of statistical expression from year to year; and the chief of those, such as fall specially within the sphere of my observation, are collected in the following table:—

	HOUSES.				New Houses, Dean of Guild Court.	Marriages.	Births.	Householders under £10 who did not pay Poor Rates.	
	Occupied.	Unoccupied.	Total.	Per cent. Unoccupied.				No.	Per cent.
1871,........................	100,876	2,154	103,030	2·09	3,851	4,617	19,390	22,341	...
1872,........................	102,748	2,230	104,978	2·12	3,717	5,121	20,913	24,008	...
1873,........................	105,043	2,744	107,787	2·54	4,564	4,911	20,202	22,993	...
1874,........................	106,906	4,451	111,357	3·99	4,768	4,992	20,963	23,219	...
1875,........................	107,483	4,918	112.401	4·37	5,006	*4,979	20,818	20,965	28
1876,........................	108,731	5,619	114,350	4·91	7,108	4,968	21,032	22,337	30
1877,........................	109,490	7,599	117,089	6·48	2,921	4,943	21,179	23,881	33
1878,........................	108,936	9,396	118,332	7·94	648	4,400	20,686	28,013	38
1879,........................	106,889	12,216	119,105	10·25	414	4,180	19,817	26,494	36
1880,........................	106,014	13,407	119,421	11·22	398	4,332	19,056	25,977	35

* Registration area extended and whole Municipality included, 1st Jan., 1875.

The number of occupied houses entered on the Assessor's roll ı June of each year increased by diminishing increments to their maximum in 1877. They then fell until, in 1880, there were 3,476 less than in 1877, 892 less than in 1874, and only 5,138 more than in 1871. The largest increment was 2,295 in 1874, the largest decrease 2,047 in 1879. There was, as we have already seen, not only a diminution in the number of houses occupied, but also in the number of inmates in each house, both as tested by the inmates per house and per room in the house. The number of unoccupied houses increased, year by year, from 2,154 in 1871 to 13,407 in 1880, from 2 per cent. of the total house accommodation to 11 per cent. The records of the Dean of Guild Court show a remarkable activity in the building of dwelling-houses, culminating in 1876, when plans for no less than 7,108 were submitted and sanctioned. From that year they fell off by "leaps and bounds" to 398 in 1880! The number of marriages in a community is a true indication of its well-being, or the reverse. The figures given above are taken from the returns of the Registrar-General, who only embraced the whole municipality in 1875. Previous to 1st January of that year those parts of Glasgow north of the Canal were not included. This makes the fact that in 1871 there were 4,617 marriages, and in 1879, within an extended area, only 4,180, more expressive than appears from the figures without this explanation. Still more expressive is the fact that the maximum was recorded in 1872, or three years before the extension of the Registration area. The lesser area then produced 941 more marriages than the greater area in 1879! The column headed Births represents the product of an area which was very slightly increased in 1872 and 1878—so slightly that the increase is practically of no moment. We find that we end the decade with a birth-product of 334 less than we had in its first year. The maximum was attained in 1877, the minimum in 1880. The last columns in the table are supplied by Mr. Campbell, City Assessor, who has spared no trouble in rendering assistance in extending and verifying my facts. They show the number of householders under £10, within the burgh, who did not pay poor-rates. The minimum was in 1875, the maximum in 1878. Unfortunately, I cannot ascertain the total number of occupancies within the burgh, under £10, previous to 1875, so that I can only reduce the absolute numbers to comparable percentages for the last six years of the decade; but this is sufficient to show that the pinch of hard times fell upon those years. The minimum of this class of householders, who were unable to pay poor-rates, was 28 per cent. in 1875, and the maximum 38 per cent. in 1878.

Allusion has been made to the remarkable extent to which Glasgow was reconstructed during the decade under review. This reminds us of the influence of the operations of the Improvement Trust in disturbing the normal growth and distribution of the community within the municipal area; and so interfering with the local and general applicability of the social data of the previous census during the currency of the last ten years. The Improvement Act was passed in 1860, but the process of demolition was not begun until 1870. The Act involved a population of over 51,000 persons, occupying some 10,000 houses. These houses have now been in great part demolished and their inhabitants dispersed; but reconstruction has not gone far, as is evident from the extensive houseless tracts of ground awaiting feuars. The Streets Improvement Act (1873) extended these operations, and the huge railway schemes of the decade have not only effected the great and beneficial work of clearing out the worst districts in the very heart of the City, but have for ever diverted from habitation enormous areas of the solum of the municipality. Added to, and in great part compelled by this, streets which formerly used to be inhabited are now converted into business premises, and the population has been still further pressed out of the municipality. There have also been great changes in the location of the chief industries of the City. The enormous rise in the value of ground has induced manufacturers to transfer their factories and workshops to the suburbs, a change which is facilitated by the convenience of railway communication extended in all directions. Glasgow has also ceased to be a centre of the cotton manufacture, which has been almost absorbed by Lancashire. The development of our staple industry, shipbuilding, with its cognate trades, has not added to the population of Glasgow proper, but has rather attracted to the suburbs the thousands of operatives employed therein. The best life-blood of Glasgow flows out along the banks of the Clyde, so that there is every prospect of the river being lined at no distant date continuously with houses and works from Glasgow to Greenock.

Taking all these facts into consideration, it is easy to understand how it comes to pass that, while the records of our Dean of Guild Court show an enormous aggregate of new houses erected during the decade, the resulting addition to our population has been so trifling. The work has been largely one of substitution of houses in other localities for those swept away from areas of the municipal solum which have been, for the most part, perpetually devoted to other purposes than those of habitation. The new houses have failed to attract the thousands who have followed the works transferred to the suburbs, or have settled alongside the shipbuilding and engineering establishments of the lower reaches of the Clyde. Had the new houses erected during the decade been the natural result of the requirements of a new population, our growth would indeed have been startling. Regarded in the true light as superior and more healthy houses, situated farther from the dense centre of the city, we cannot but look with satisfaction on the following facts. From the column in a preceding table which shows the yearly number of houses in the tenements, the plans of which passed the Dean of Guild Court, it will be seen that the aggregate amounts to 33,395 in the ten years. The nett increase in the number of houses, occupied and unoccupied, is only 16,390, so that the balance, or 17,000, represents the extent to which this building has been a mere work of substitution. These *new houses* alone would have accommodated a population of 158,000 souls ! yet the *new population* only amounted to some 20,000, and we have now a balance of empty houses on hand sufficient to put up more than three times the numbers added to our population during the last ten years. Of the 119,000 occupied and unoccupied houses in existence on 4th April, 1881, no less than 28 per cent. had been built during the previous ten years ! In fact, if we go back as far as the accessible information permits—viz., to 1866—we find that 45,544, or 38 per cent. of the houses now in existence, have been built since that date. That is to say, supposing on 1st January, 1866, the first stone of this new Glasgow had been laid, if the population had increased in proportion, we should now have a city only 13,000 less than the Edinburgh of to-day, and as populous as Glasgow with all its suburbs in 1831.

My present concern with all these facts is not to estimate their social or even their general sanitary importance, but their bearing on the census, and the deductions therefrom, as a basis for the vital statistics of the decade. It must be admitted that no more complicated problem could be presented to the statistician than is involved in an effort to obtain a firm footing in the midst of such internal revolutions. Still, the attempt must be made; and it seems to me that these facts point with singular unanimity to one conclusion—that the decade may be divided into two periods of five years, the first of which were years of prosperity, the last years of adversity. Increase more or less marks the former period, decrease more or less the latter. The first five years close with an increase of 6,607 inhabited houses, the last five years with a decrease of 2,717: the first close with 4·37 per cent. empty houses, the last with 11 per cent. In the first period nearly 22,000 new houses were built, in the last little more than half that number. At the close of the first period, there were unoccupied houses sufficient to accommodate 23,000 people: at the close of the second, sufficient for 63,000. In the first period there were 24,620 marriages, in the second period 22,823 in a larger area. In the first period there were 102,286 births, in the last only 101,770. In the first there were 113,526 persons occupying houses under £10 rental who were unable to pay poor-rates, in the second 126,702 in a less population. In the first period, as a matter of history, trade was certainly declining, but in the second we had the culminating crash of the bank failure and the clamant thousands of unemployed.

I propose, therefore, to estimate the population of the first period on the basis of facts ascertained at the census of 1871, and of the second period on the basis of facts ascertained at the census of 1881. Whatever doubts and uncertainties may attend the intervening years, we rest upon certainty at the beginning and at the end. The number of persons found in each occupied house in 1871 was 4·793, in 1881 4·138. It seems fair, therefore, to presume that, during the five prosperous years, the multiplier 4·793 may be applied to the occupied houses of each year, and during the five adverse years the multiplier of 4·738 - adding to the result in the former 6,867, in the latter 7,776, the number of persons actually enumerated in institutions and in the vessels in the harbour in 1871 and in 1881. The following, then, are the respective populations, deaths, births, death-rates, and birth-rates, derived from those populations in each year of the decade:

	Revised Estimates of Population.	Deaths.	Death-Rates.	Births.	Birth-Rates.
1871	490,442	16,155	32·90	19,390	39·53
1872	499,338	14,357	28·75	20,913	41·88
1873	510,338	14,576	29·14	20,202	39·58
1874	519,267	16,323	31·43	20,963	40·37
1875	522,033	15,287	29·28	20,818	39·87
1876	522,943	13,688	26·17	21,032	40·21
1877	526,540	13,758	26·12	21,179	40·22
1878	523,914	14,055	26·82	20,686	39·48
1879	514,216	12,450	24·21	19,817	38·53
1880	510,070	13,303	26·08	19,056	37·35
Average	513,910	14,425	28·07	20,405	39·70

I shall only refer to the mortality. The mean population of the decade was 513,910, the mean number of deaths per annum 14,425, and the mean death-rate 28 (28·07) per 1,000 of the population. The mean death-rate of the decade 1861-70, as finally adjusted by the Registrar-General, was 30 (30·29). There has therefore been a diminution of fully two deaths per 1,000 living—that is to say, 10,278 persons are alive who, at the death-rate of the previous ten years would have been dead.

If we compare the first and last periods of five years by taking their mean populations and deaths, we get the following results:—

1871-75,	508,284	15,399	30·29 (30).
1876-80,	519,536	13,451	25·89 (26).

The death-rate of the first period was 30, of the second 26, showing a diminution of 4, or exactly 4·4 per 1,000 living, so that the whole aggregate saving of life was effected amid the circumstances of dull trade and general destitution which characterised the close of the decade.

In what direction did this lowering of our death-rate come—in which classes of disease has this saving of life been effected? I have prepared two tables which answer this question—one giving the number of deaths in each year of the decade from certain causes, the other giving the death-rates from those causes.

These tables, then, prove that the most marked feature of the last, as compared with the preceding ten years, has been the diminished fatality of all forms of infectious or zymotic diseases. Only 7 in place of 20 persons out of every 10,000 of the population died of fevers; only 1 in place of 2 died of small-pox; only 9 in place of 13 died of scarlet fever; 7 in place of 8 of measles; 12 in place of 15 of hooping-cough; 5 in place of 6 of croup and diphtheria; 8 in both periods from diarrhœal diseases. On the other hand, the mortality from diseases of the lungs only fell from 102 to 99; while the mortality from miscellaneous, unclassified causes, rises from 127 to 129—thus all but neutralising the gain from the small diminution in the pulmonary fatality, and leaving almost the whole balance of gain in the ten years to the credit of the diminution in the fatality of infectious diseases.

An encouraging feature of this improvement in respect of infectious diseases is this—that it is progressive. If we divide the last decade into two periods of five years, and compare therewith the period 1861-70, in the case of every one of these diseases, we find that the last period of five years (1876-80), shows the lowest mortality. The fevers carried off, per 10,000 of the population, 20 in 1861-70; 9 in 1871-5; 5 in 1876-80; and (in each following the same succession of periods) small-pox, 2-3-·7; scarlet fever, 13-15-5; measles, 8-8¾-5½; hooping-cough, 15-13-12; croup and diphtheria, 6½-6-5½; diarrhœal diseases, 8-9-7. But for the great milk epidemic of enteric fever in 1880, originating in the disgraceful sanitary arrangements of a farm twenty miles away, which has left its mark in a rise of 2½ per 10,000 on the fever death-rate of 1880, the decade which began with a fever death-rate of 16 per 10,000, might be said to have recorded an almost continuous fall year by year, until it closed with one of only 4.

The only black spot in our death-roll is the death-rate from diseases of the lungs. It also was least in the last of the three periods, the rate per 10,000 being in each in succession, 102½-105-93½, but considering the large proportion contributed by this class of diseases to the aggregate mortality, this is but a slight improvement. The proportion is in fact increasing. In the period 1861-70, diseases of the lungs contributed 34 per cent. of the total deaths; in the period 1871-75, 34½ per cent.; in the period 1876-80, 36 per cent. These diseases, under certain conditions of aggravation of their physical causes, by intense cold and fog, may produce a death-rate for certain years, which would be reckoned high in a country district as the aggregate death-rate from all causes. Nor does the number of deaths directly ascribed to pulmonary diseases fully measure their deadly influence. No physician can have any doubt that the same physical causes which produce death from affections of the lungs, pure and simple, complicate and add greatly to the fatality of infectious diseases in Glasgow, besides increasing the number of deaths from miscellaneous causes, by the secondary effects of lung disease upon the heart, brain, and other organs of the body. While we are attacking zymotic diseases upon their own ground with some success, we have not yet struck home against the causes of our pulmonary death-rate, which are an atmosphere surcharged with smoke, and crippled in its powers of self-renewal by over-density of building, and overcrowding of the inhabitants, with a low level of household comfort.

		Small-pox.	Scarlet Fever.	Measles.	Hooping-cough.	Croup and Diphtheria.	Diarrhœal Diseases.	Consumption and Acute Diseases of Lungs.	All other Diseases.	TOTAL.
1871, ...	787	205	345	889	540	343	419	6,201	6,426	16,155
1872, ...	430	137	372	109	1,056	315	378	4,957	6,603	14,357
1873, ..	340	223	602	614	313	348	534	4,795	7,107	14,876
1874, ...	343	221	1,719	274	676	280	468	5,220	7,122	16,323
1875, ...	382	2	729	341	692	272	520	5,462	6,887	15,287
1876, ...	311	7	315	297	611	260	463	4,925	6,499	13,688
1877, ...	262	11	132	359	424	345	263	5,285	6,677	13,758
1878, ...	261	2	190	280	985	261	483	4,999	6,594	14,055
1879, ...	198	...	248	156	482	263	228	4,700	6,175	12,450
1880, ...	332	2	453	331	709	282	420	4,387	6,387	13,303
1871-75,	2,282	788	3,767	2,227	3,277	1,558	2,319	26,635	34,145	76,998
1876-80,	1,364	22	1,338	1,423	3,211	1,411	1,857	24,296	32,332	67,254
1871-80,	3,646	810	5,105	3,650	6,488	2,969	4,176	50,931	66,477	144,252

DEATH-RATES PER 10,000 FROM CERTAIN CAUSES IN DECADE, 1871-80.

Years.	Fevers.	Small-pox.	Scarlet Fever.	Measles.	Hooping-cough.	Croup and Diphtheria.	Diarrhœal Diseases.	Consumption and Acute Diseases of Lungs.	All other Diseases.	TOTAL DEATH-RATE.
1871, ...	16·04	4·17	7·03	18·12	11·01	6·99	8·54	126·43	131·02	329·0
1872, ...	8·61	2·74	7·44	2·18	21·14	6·30	7·57	99·27	132·20	287·5
1873, ...	6·66	4·36	11·79	12·03	6·13	6·81	10·46	93·95	139·25	291·4
1874, ...	6·60	4·25	33·10	5·27	13·01	5·39	9·01	100·52	137·15	314·3
1875, ...	7·31	0·03	13·96	6·53	13·25	5·21	9·96	104·62	131·92	292·8
1876, ...	5·94	0·13	6·02	5·67	11·68	4·97	8·85	94·17	124·27	261·7
1877, ...	4·97	0·20	2·50	6·81	8·05	6·55	4·99	100·37	126·80	261·2
1878, ...	4·98	0·03	3·62	5·34	18·80	4·98	9·21	95 41	125·85	268·2
1879, ...	3·85	...	4·82	3·03	9·37	5·11	4·43	91·40	119·90	242·1
1880, ...	6·50	0·03	8·81	6·48	13·90	5·52	8·23	86·00	125·21	260·8
1871-5,	8·97	3·08	14·81	8·75	12·88	6·11	9·12	104·80	134·34	302·9
1876-80,	5·25	0·07	5·13	5·46	12·35	5·42	7·14	93·52	124·46	258·9
1871-80,	7·09	1·57	9·82	7·10	12·60	5·75	8·11	99·10	129·14	280·7
1861-70,	20·24	2·32	13·17	7·95	[illegible]	6·62	8·13	102·40	127·02	302·9

III.—*Report by* DR. HENRY MUIRHEAD, *one of the Delegates from the Society to the gathering of Delegates from other Scientific Societies attending the Meeting of the British Association at York, in August,* 1881.

[Read before the Society, 30th November, 1881.]

HAVING been appointed a delegate to the meeting of the British Association at York, to co-operate with our President and Secretary, I attended a meeting of delegates from various scientific societies of the United Kingdom. From this meeting, held on the 6th September, in the Museum of the Philosophical Society of York, our President and Secretary were unfortunately unavoidably absent. It therefore devolves on me to make a short report.

Mr. Whitaker, of the Norwich Geological Society, occupied the chair. The following report of the committee appointed at a conference of delegates from scientific societies at Swansea, in August, 1880, was read, and after discussion adopted, as was the resolution embodied therein:—"We have to report that we have issued to all the scientific societies of the United Kingdom entitled to send delegates to the British Association a circular-letter inviting these societies to send delegates to the York meeting, and that, in connection with this, we have been engaged in a considerable amount of correspondence. We have also to report that, in order to place these conferences on a firmer basis than could otherwise be done, and to meet the necessary expenditure, we had proposed the appended resolution—that this resolution has passed the committees of sections A, C, and D, and will be brought before the committee of recommendations to-day—that a committee be appointed, consisting of Sir Walter Elliot, F.R.S., Mr. H. George Fordham, Mr. John Hopkinson, Mr. G. J. Symons, F.R.S., and Mr. W. Whitaker, to arrange for a conference of delegates from scientific societies, to be held at the annual meetings of the British Association, with a view to promote the interests of the societies represented, by inducing them to undertake definite systematic work on a uniform plan; that Mr. Fordham be secretary, and that a sum of £5 be placed at their disposal for the purpose."

It came out in the course of the discussion that some dissatisfaction had been expressed by certain members of the executive of the British Association, because the delegates' committee had placed the words "British Association" at the head of the printed circulars. This, among other reasons, led to the sending the foregoing resolution to the committee of recommendations, with the view to attain some recognised connection with the British Association. And I am glad to be able to say that the resolution —though minus the money—did pass the committee of recommendations, so that now it is all but certain that the delegates' conferences have acquired a *locus standi* affiliated to the parent association.

As no money was accorded, it was proposed and agreed to that each society sending delegates should authorise the payment of an annual sum (not exceeding 10s.) to defray the expenses of the committee in printing and posting circulars, and other incidental expenditure.

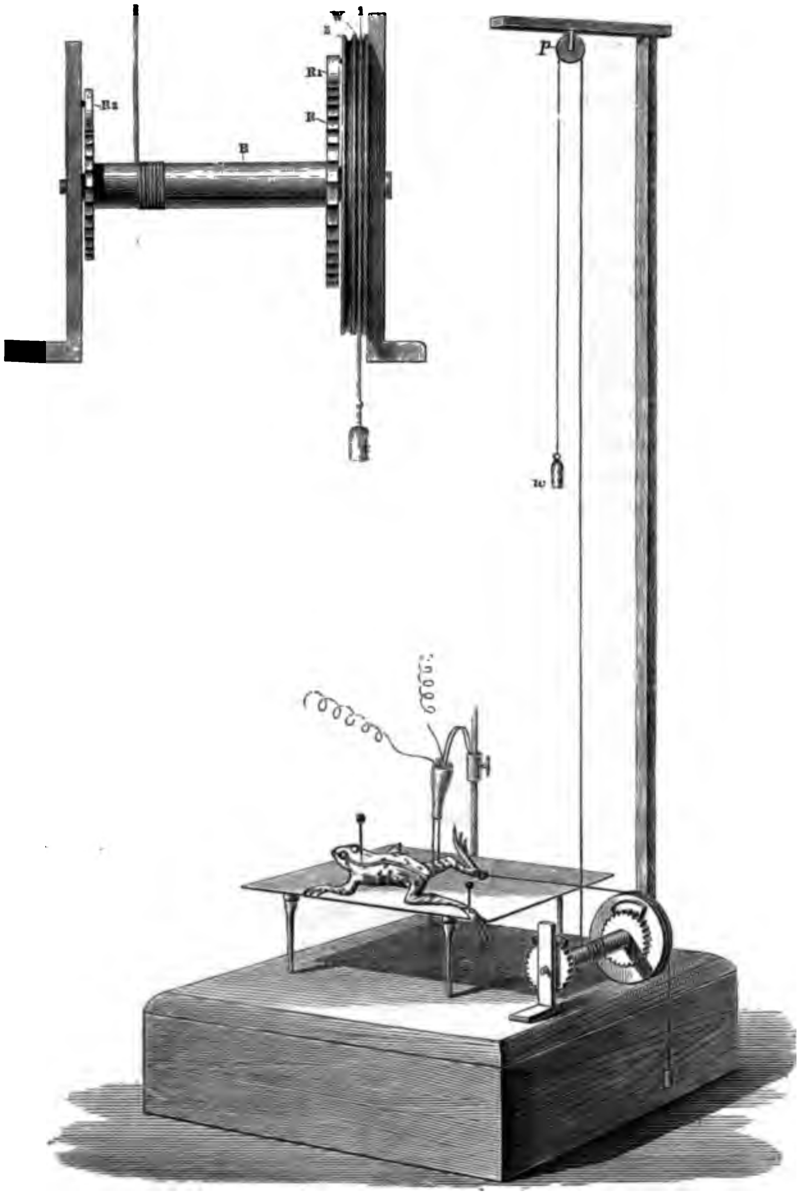
An interesting discussion took place as to the best methods of stimulating local societies to more active work, such as the recording the migration of birds, appearance of insects, and other periodical phenomena, observation of rainfall, luminous meteors, underground circulation of water, &c. Perhaps I ought to mention that our member, Mr. J. B. Murdoch, F.S.A., was present as a delegate from the Geological Society of Glasgow, and took an active part in the discussion.

IV.—*On an Apparatus for Studying the Work done by a Frog Muscle.* By J. McGregor-Robertson, M.A., M.B., Muirhead Demonstrator of Physiology in the University of Glasgow.

[Read to the Society, 30th November, 1881.]

The accompanying woodcut gives a sketch of an arrangement designed to show the work that can be performed by a muscle in the shape of lifting a weight.

It consists of a winch, to the barrel (B) of which a thread is fixed



by a small eye. The thread passes directly upwards to a pulley, fixed some four or five feet above it. After passing over the pulley the thread is attached to a weight, the amount of which is varied at pleasure. To one end of the barrel is attached a wheel (W), which has two grooves (1 and 2) running in its edge. The wheel is so attached to the barrel that it can move easily in either direction. When it moves in one direction, by means of a spring and pinion (R¹), it catches on the toothed edge (R) of the barrel and turns it with it, thus winding in the thread. When it moves in the other direction, it moves alone, having then no catch on the barrel, while the barrel is prevented from slipping backwards by a catch (R²) fitting into another toothed edge at the other end.

In the grooves of the wheel there lie two threads, fastening by means of little eyes. One thread passes over the wheel in one direction, and is attached to the gastrocnemius of a frog lying on a Marey's frog-plate. The other thread passes over the wheel in the opposite direction, and is allowed to hang straight down, having a weight attached to it.

The wheel is thus under the influence of two opposite forces—the first, the force of the contracting muscle. When the muscle contracts the wheel is pulled round, the barrel is turned in the same direction by means of the catch, the thread is wound in, and the weight at its end lifted by a corresponding amount. As soon as the contraction is over and the muscle relaxes, the wheel comes under the influence of the opposite force—*i.e.*, the weight hanging from it. It is, accordingly, pulled round to its original position. The thread attached to the muscle is thus rendered tense, ready for another contraction, while the barrel is prevented from turning backwards by the catch already mentioned.

In arranging the apparatus for a demonstration, the pithed frog is laid on Marey's plate in the usual way, the sciatic nerve being stimulated by secondary shocks. In the primary circuit of a Daniel's element a revolving cylinder is interposed, which forms the circuit two or four times a minute. The muscle thus gets regularly two or four shocks per minute. The arrangement having been made, the experiment can be allowed to work away without interruption for half-an-hour or more. At the end of the experiment the weights attached to the wheel and pulley, multiplied into the distance through which they have been lifted, give the work done. The arrangement is used merely for purpose of demonstration, and is, I am afraid, rather rough for giving strictly accurate results.

FOOT-NOTE.—The figure in the upper left-hand corner of the woodcut is a view of the winch. The other figure shows the frog in position, with hook attached to thread, through Tendo Achilles, and the electrodes passing down to the sciatic nerve. Part of the wires to the secondary coil is shown.

V.—*Microbes in Fermentation, Putrefaction, and Disease.* By Charles Cameron, M.D., LL.D., M.P.

[Read before the Society, 14th December, 1881.]

Microbe is a word with which the recent researches of M. Pasteur into the intimate pathology of fowl cholera and splenic fever have made the public of this country more or less familiar. It was originally introduced by Sedillot as a convenient and non-contentious name for various minute organisms found in the fluids or tissues of the body in certain diseased conditions. As generally employed, its use is confined to them. As we shall see, however, that precisely similar organisms are inseparably connected with the processes of fermentation and putrefaction, and in certain cases that specific organisms associated with these processes, when they find their way into the animal economy, give rise to specific diseases, I see no reason why the use of the word should be so restricted, and shall apply it indifferently to-night to the minute organisms which play such a prominent part in the whole three classes of phenomena. Though these microbes are generally believed to belong to the vegetable world, in lower regions of life the boundaries between the animal and vegetable are very indistinct, and there are many microbes which display so much activity and such an apparent intelligence in the direction of their movements, that it is difficult not to share the sentimental preference to which Pasteur gives expression for placing them in the same kingdom as ourselves. They consist of cells of different sizes and shapes, which multiply themselves with enormous rapidity and are characterised by a considerable resistance to various reagents, such as ammonia, concentrated acetic acid, &c., which destroy animal cells, a characteristic of which the microscopist avails himself in his demonstrations when he has to deal with them in animal tissues. They have been elaborately classified by certain botanists; but experience shows that in many cases they vary in form according to the medium in which they are found, and some of them possessing the most distinctive properties, like the fermenting and non-fermenting torulæ, for example, are undistinguishable under the microscope.

As my principal aim is to call attention to recent researches regarding their connection with disease, under circumstances where their vital reactions are of supreme importance, I shall not waste time in attempting any description of their morphological differences, and shall content myself with roughly indicating the general characteristics of some of the species of organisms to which I shall most frequently have occasion to refer. I shall have to speak of the *torula* or yeast plant, a spherical or ovoid organism of which there are various species, varying very much in size; the *micrococcus*, a family of which there are also innumerable species, presenting the most diverse characters—sometimes found in the form of separate spherical cells; sometimes of chains or bunches of cells held together by a gelatinous bond; sometimes gliding over the field of the microscope by a combined sinuous movement; sometimes jerking upon their bonds of union with a rhythmical movement which has been compared to the brandishing of a shillelagh. Again, we have the *bacterium*—a rod-like group of microbe—of which some species are hundreds of times larger than others; the *vibrio*, an elongated cell, often manifesting the most lively movements, swimming about like a tiny eel, and presenting itself in as many shapes as a leech. Of all these groups there are many species, some of which have been carefully studied and identified, but the vast mass of which are as yet to be described and classified.

Now, I need not tell you that of late years these microbes have been shown to play a most important part in many diseases; but their characteristics naturally admit of much more accurate and exhaustive study in the processes of fermentation and putrefaction than when they are complicated and obscured by the disturbing influences of organised life. If, therefore, we wish to understand their functions in disease, we must, in the first place, consider what is known regarding them in the other processes in which they intervene. I accordingly propose to direct your attention to certain points in connection with their intervention in fermentation and putrefaction, which seem to be essential to anything like a clear understanding of their effects in disease. And if I seem to dilate at too great length upon this branch of my subject, my apology must be that in this country the purely chemical teachings of Liebig regarding fermentation have left so deep an impression that, even at this moment, they cause the vast majority of us to overlook the importance of the antagonistic and vital theory of Pasteur—a theory which has directly led that scientist up to the wonderful results with which the world has recently been startled into amaze.

The amount of pure yeast which can be taken upon a pin's point will suffice to accomplish the fermentation of an unlimited quantity of wort. The reason is that the yeast cell is a living plant, and grows so long as it finds material to feed on, and its growth under proper circumstances is accompanied by the decomposition of the sugar contained in the wort into alcohol and carbonic acid. The life of the plant and the decomposition of the sugar are cause and effect. Boil the yeast and no fermentation will result on its introduction. Destroy its cells by rubbing them on a ground glass plate and the same thing results. Retard its growth by cold, and the decomposition of the sugar is retarded; accelerate it by heat, and the production of alcohol is accelerated; kill it by compressed oxygen or in any other manner, and the fermentation stops. But the yeast plant is far from the only plant which is capable of giving rise to this decomposition, and under certain circumstances it fails to give rise to it. In the first place, there are a number of yeasts doubtless descended from some common ancestor but presenting specific differences, giving rise to slightly differing products, and incapable of transformation one into the other. The ordinary yeast plants of our breweries produce spores only under extraordinary circumstances of artificial cultivation, but the microbes which give rise to the alcoholic fermentation of the bruised grape are produced by spores which are self-sown, which develop ferment cells only at certain seasons, and whose origin is to a large extent shrouded in mystery. Various moulds, submerged beneath the surface of the saccharine fluid in which they vegetate, and so deprived of the oxygen which, under normal circumstances, they derive from the air, continue to live, and extracting that oxygen from the sugar amid which they are plunged, give rise to the formation of alcohol and carbonic acid. In forming the sugar which abounds in ripened fruits, the unripe fruit absorbs oxygen from the air. If the ripening fruit be placed in an atmosphere of carbonic acid, cell life continues to go on in its interior, but the process is reversed. The cells appropriate the oxygen, of which they have need, from the sugar already formed around them, and the production of alcohol and carbonic acid again results. Even in fresh meat, where organic cell-life continues formed long after the animal from which the meat was cut has perished. Béchamp has found alcohol—doubtless the result of an analogous vital process. Nay, within the present year M. Muntz, by a delicate reaction, has shown that alcohol, in minute quantities, is to be found everywhere in nature—a result of the decomposition of organic matter by the ferments which everywhere exist. What is the explanation of all this? I can conceive none other satisfactory than that given by Pasteur years before many of the facts I have mentioned were known. "The character of ferment," he says, "presents itself to us not as proper to such and such an organism or such and such an organ, but as a property of the living cell, a character always ready to manifest itself, and really manifesting itself as soon as life is not accomplished under the influence of free oxygen gas, or of a quantity of this gas insufficient for all the acts of nutrition. One sees it commence and cease with this species of life—slight and of feeble duration if the species of life is the same; intense, on the contrary, and of long duration, furnishing large quantities of alcohol and carbonic acid, when the plant, the organ, or the cell can multiply itself with facility under the new conditions. Thence all imaginable degrees of fermentation, and thence also the existence of ferments of all forms and of very different species. One can even imagine without difficulty," he goes on to say, "that the decomposition of sugar should be altogether different from that of which we have spoken, and that, in place of alcohol and carbonic acid, it should give glycerine, &c., or lactic, butyric, acetic acid, &c. This would occur with a certain class of cellular vegetables, more or less analogous to those which decompose sugar into alcohol and carbonic acid. Others specifically different would act in a different manner. In a word, so many beings, so many different ferments." Fermentation of this class is then a process inseparably connected with the functions of life. In certain cases, as in ordinary acetic fermentation, the microbe takes the oxygen which it requires from the air, and with it burns the combustible portion of the nutriment it assimilates, giving off carbonic acid, and leaving behind a compound of proportionately higher oxidation. In another class of fermentation the microbe falls back upon the oxygen of the organic compounds in which it is found, appropriating that to the purposes of its own development, and reducing them to a state less rich in oxygen. And the same organism may, under certain circumstances, act in one manner or the other. Thus the mycoderma aceti, which is certain circumstances reduces sugar to alcohol, will, under others, oxidize alcohol into acetic acid. But, although there are certain of these organisms or microbes which accommodate themselves with great seeming indifference to either mode of life, there are others essentially aerobic or anaerobic—for which free oxygen is a necessity or a poison, which can apparently be more or less successfully trained into tolerating or dispensing with it under certain conditions of development and cultivation, but which, under the circumstances in which we are ordinarily acquainted with them, display of their energies only in one direction and in a specific manner. Thus the *torula cerevesiæ* in the everyday development of its life resolves sugar into alcohol. An organism very similar in appearance, but much smaller, produces lactic acid. A third, the *microderma aceti*, oxidizes alcohol into acetic acid. A fourth, a lively vibrio, reduces fermentable matter to butyric acid with the liberation of hydrogen, which, when the matter fermenting contains phosphorus or sulphur, unites with them and produces the unsavoury odours characteristic of putrefaction. Another organism again—a little micrococcus—decomposes urea into ammonia, and hippuric acid into benzoic acid and glycocole. The transformation of tannic acid into gallic is the work of a sixth. The artificial conversion of ammoniacal waters into nitre appears to be due to the intervention of a seventh. And I might mention as many more instances of specific fermentation without exhausting the list of those of which the specific microbe has been demonstrated or studied.

We are now in a position to turn to the process of putrefaction, and to understand precisely what that is. In a sentence, putrefaction is neither more nor less than a process of impure and mixed fermentation, the products of which vary according to the species of the ferments which happen to have been sown, the nature of the soil on which they find themselves, and the circumstances in which they are placed. A certain step in the reduction of organic matters to their elements is effected by one ferment. The new compound is taken up by a second, and advanced a stage further on the way to dissolution. That again is laid hold of by a third, until finally the organic structure is reduced to its original inorganic elements, and these are set free, once more to enter on a new cycle of life. A microbe which plays a leading *rôle* in this great work of reorganisation is the vibrio of butyric fermentation. To the fully-developed organism oxygen is

[illegible] liquid
[illegible] they are
[illegible] But
[illegible] vitality.
[illegible] into
[illegible]
[illegible] supply
[illegible] upper surface.
[illegible] supplying
[illegible] of the oxygen
[illegible] and water.
[illegible] according to
[illegible] is the
[illegible] possess the faculty of
[illegible] was the
[illegible] those to-day.
[illegible] the conve-
[illegible] their dissolution—a
[illegible] organs so dissolved of
[illegible] very [illegible], and
[illegible] But to return to my text.
[illegible] fermentation, why have I
[illegible] processes as if they were distinct?
[illegible] phenomena of microbe life
[illegible] of fermentations con-
[illegible] of infinite practical
[illegible] studied in connection with
[illegible] the problem of so-called spont[illegible].
[illegible] Now I am far from inappreciative of th[illegible]
[illegible] work in the field. He has brought
[illegible] facts, and the pertinacity and [illegible]lo-
[illegible] maintained his favourite theory has led
[illegible] rigorous methods of investigation, which
[illegible] Harveyan maxim *omne vivum ab ovo* o[illegible]n a
[illegible] than it ever stood on before. No one
[illegible] of Professor Tyndall can doubt that
[illegible] of spontaneous generation is dead, but in the investi-
gations and discussions which have led to its death, knowledge of
infinite value has been evolved. I need not tell an educated
audience like this that it is now established beyond all contesta-
[illegible] that, preserved from contact with microbes or their germs,

the most putrescible bodies exposed for years to contact with the atmospheric air will remain unputrefied. I need not tell you that, under such circumstances, meat in contact with the air will undergo certain changes, but will not rot. Blood will disintegrate, its corpuscles will fall to pieces, and salts will crystallise out, but it will not putrefy. Wort will oxidize, but it will not ferment; and animal and vegetable infusions will remain for years without apparent change. But, in establishing these facts, it has been proved that the most extraordinary difference exists between the tenacity of life exhibited by the developed microbes and the spores or germs from which they spring. Submit the microbes to a boiling heat, or, in many instances, to a heat far short of the boiling point, and they are killed. Dry them, and in many cases they die at once, and in all in a comparatively short time. Expose certain of them to the oxygen of the air, and they perish. Saturate the fluid in which others are found with carbonic acid, and they are paralysed; and though for a time capable of revival by oxygen, ultimately succumb. Expose any of them to oxygen under high pressure, and they are asphyxiated. Dilute solutions of antiseptic agents kill them. But as to the spores which they produce, and from which succeeding generations spring, there is almost no killing them. The more you dry them the better they resist destruction. Time is no object with them, and they maintain their dormant vitality for an indefinite number of years. Absolute alcohol has no effect on them; as to oxygen, they can stand that concentrated by the pressure of twenty atmospheres, and be none the worse. Two or three hours' boiling, if they have been well dried beforehand, seems not to hurt them, and they have been even known to survive eight hours of the process. The only effectual means for their immediate destruction that I am aware of is the flame of a spirit lamp. To that their extreme minuteness renders them an easy prey. Now, how, you will ask, does it come, when these germs can stand so much rough handling without destruction, that mild solutions of such harmless antiseptics as carbolic acid or borax, or permanganate of potash, can have any effect in preserving us against the mischief they work? This strikes me as a most important point in connection with medicine and surgery, but I have never seen it noticed. Professor Tyndall's experiments, however, appear to afford a very simple explanation. That gentleman took infusions infected with spores or germs derived from old hay, on which many hours of continuous boiling had no effect, and found that by boiling it for a single minute, or fraction of a minute, at intervals of a few hours, he could, with an aggregate of five minutes' boiling, sterilise the most refractory infusion. The explanation is obvious. The spores in an infusion are in different conditions as to species, age, dessication, exposure to air and light, &c., and they will naturally require different periods for germination. While they remain simple spores they resist prolonged boiling. But allow them to germinate, and deal with each successive crop as it is springing into life, and your victory is of the easiest. In the same way we can easily see how any solution which will kill the developed microbe can preserve the decoction or wound in which it is placed from the development of microbes. It may not kill their refractory germs, but it will kill them off in detail as they spring into life. The point has a most evident bearing on the rationale of the disinfection of articles containing the germs of the microbes of disease, and, I can't help thinking, urgently demands a much more stringent experimental investigation than it has hitherto received.

But what has all this talk about these microbes and their germs got to do with the subject of disease? In 1879, M. Marix made some experiments upon the action of ordinary yeast on blood outside the body. He found that it multiplied itself freely, depriving the blood corpuscles of their oxygen, and reducing them to a dark brown colour, and that it decomposed the sugar of the blood into carbonic acid and alcohol. He then tested its effect when introduced in suspension into the circulation of the living animal, and found that when more than two grammes of it was injected the result was always fatal, while in doses below two centigrammes, on the contrary, it was almost innocuous. Between these doses the effects observed were very characteristic. There was an elevation of temperature, followed by a depression often extreme, and the animal became comatose. Almost immediately after the injection the subject of the experiment was seized with a diarrhoea strongly resembling that of typhoid fever, and after death the glands of the intestines, known as Peyer's patches, were found engorged and ulcerated precisely as in that disease. The blood was not altered in colour, showing that within the living body its corpuscles had sufficient energy to enable them successfully to contest that element with the yeast plant, but every trace of sugar had disappeared from it. In non-fatal cases there was the same fever, the same glairy and sanguinolent diarrhoea, in which the yeast globules were apparently eliminated, for after a few days they were not to be found in the blood.

When Pasteur discovered that the fermentation which changes urea into ammonia was due to the presence of a specific micrococcus, he ventured to assert that to the same microbe, and not to the decomposition of effused mucus, would be found to be due that formation of ammoniacal urine within the bladder which in cases of retention of that fluid gives rise to such distressing symptoms. This, subsequent observation has proved to be the case. Ammoniacal urine is as much the disease of the *micrococcus ureæ* as itch is the disease of a specific acarus.

Coming now to the ordinary microbes of putrefaction, we all know by what a remarkable process of analogical reasoning a former fellow-townsman of our own grasped the fact of the important part they play in surgical disease, and how—without more knowledge of their individual peculiarities than could be gained by a perusal of Pasteur's memoir on lactic fermentation—Lister laid the practical foundations of that great principle which has made him famous throughout the civilised world, and will give reason to countless generations to bless his name. The success which has attended his practice affords to the general public the most convincing proof of the correctness of his theory. This is not, however, sufficient for the man of science. But M. Chauveau, a veterinary surgeon of Lyons, who first demonstrated that infections were not liquid or gaseous but particulate, and whose many invaluable researches into the intimate phenomena of contagions are far too little known in this country—devised a demonstration which sets the matter beyond all question. For the production of wether mutton in France recourse is had to an operation known as bistournage. This consists of the rupture of the spermatic cords by torsion, cutting off the testes from all communication with the circulation, but leaving surrounding tissues uninjured. In this operation the glands do not putrefy, but in time become adherent to the surrounding tissues, and undergo a species of fatty degeneration. This is what one would expect, for we have seen that without the intervention of microbes putrefaction will never occur. But Chauveau reasoned that if these were really the cause of putrefaction you should be able to produce it in the glands killed by the operation, though within the living body, by introducing these microbes into them through the circulation previous to its performance. He accord-

[illegible] into the jugular vein of a sheep a quantity of fluid charged with microbes of putrefaction, which experience had taught him was insufficient to kill the animal, and then performed bistournage. Before he had done so the microbes had found their way into the testes and these putrefied. But was the putrefaction produced by the microbes or by the fluid in which they had been [illegible] the circulation? He filtered the liquid so as to separate the microbes, repeated the operation, and the result was nil. [illegible] bistournage on one testis so as to sever [illegible] circulation, injected the decomposing fluid, and then performed bistournage on the other side. The gland that had been [illegible] the access of the microbes by bistournage previous to [illegible] the animal remained sound; that into which they [illegible] their way previous to the operation [illegible].

[illegible] putrefaction as consisting of a varying mass of [illegible], and if this theory is correct—and I am not [illegible]—from what we now know of the action [illegible] we should expect that the septic disease resulting from the [illegible] or absorption of putrefying matter [illegible] a very complex nature; and so it turns [illegible]. Pasteur has described two principal forms of it, and the [illegible] in human beings, while Koch has identified [illegible] lower animals, and it seems certain [illegible]. Koch's researches illustrate [illegible] disease, and as the adoption of a [illegible] promises great results [illegible] at some little length. [illegible] germs in the air it is [illegible] precaution, to obtain [illegible] purity. The yeast of commerce is [illegible] in a short time to produce [illegible] fermentation. The superior vigour of the yeast plant prevents the microbes of these fermentations from [illegible] alcoholic fermentation is going on with energy, but under certain circumstances they occasion great loss to our brewers. To separate different ferment microbes from each other you avail yourself of the fact that different species thrive best in different soils. One grows most vigorously in an acid infusion, another in an alkaline. Oxygen is fatal to one, carbonic acid to another. Tartaric or phenic acid will kill off some species more rapidly than others, and so by repeated cultivation in conditions favourable to this or that form of microbe, and prejudicial to those with which it is found associated, you get what you want. To analyse a disease which, like septic poisoning, may result from a number of microbes, you must resort to a similar process. Some of these flourish in one animal or cultivation fluid, but die in another, and on that principle the analysis can be made. Koch, for instance, found that by injecting a drop of putrefying matter into the circulation of the common mouse, death resulted in 40 to 60 hours, and two distinct phenomena presented themselves under the microscope. The blood swarmed with vibrios of extreme minuteness, and a micrococcus arranged in peculiar chains, the smallest which Koch has ever seen, was found in the serum at the point of inoculation. On the ordinary mouse it was impossible to separate this latter microbe from the other, but by inoculating them on the field mouse Koch found that the vibrio perished and the micrococcus gave rise to a peculiar gangrene. Neither of these microbes affected the rabbit. Coze and Feltz, on the other side, selected that animal for their experiments, and they found that the inoculation of a few drops of putrefying matter into its circulation caused the blood to swarm with certain other microbes. But the curious point brought out by their experiments was that by repeated cultivations of these microbes in the rabbit they could enormously increase their virulence. Thus, having injected from 1 to 10 drops of blood putrefied in the air into the veins of each of 48 rabbits they found that 26 of them died. Injecting 1 to 4 drops of the blood of one of the rabbits dead in this experiment into a number of others, they found that all inoculated perished. Following the same procedure, they found that at the fifth generation one-hundredth part of a drop killed the animal in less than 20 hours. At the tenth generation they could kill a rabbit with the 20,000th part of a drop, and in subsequent generations with even smaller amounts. Toussaint claims to have proved that the organism thus cultivated out is none other than the microbe of fowl cholera, of which we shall speak hereafter.

The two forms of septic disease investigated by Pasteur are human septicemia and pyemia. In the first of these he has discovered a septic vibrio wonderfully akin in many respects to the microbe of butyric fermentation. Like that microbe, oxygen kills it, but like it, too, its germs are unimpaired even by compressed oxygen. They will germinate in carbonic gas, or even in vacuo. Like it, too, it manifests its fermentative action by the liberation of hydrogen and carbonic acid. Its habitat *par excellence* is in the serum of the abdominal cavity, and in the muscles of the abdomen. It does not pass into the blood till the last stage of the disease or after death, and in that fluid it assumes an aspect of immoderate length, frequently passing beyond the entire field of the microscope, and a translucidity so great that it often escapes observation. When, however, adds Pasteur, one has once seen it, it can easily be found "creeping, flexuous, and separating the globules of the blood as a serpent separates the grass in a thicket." This microbe does not give rise to the formation of pus, but apparently poisons its victim by the production of an alkaloid which Bergman has named sepsine. The second form of septic organism, described by Pasteur, is the pyogenic. It is evidently identical with the micrococcus which forms the principal subject of an able and interesting memoir by Dr. Ogston, of Aberdeen. It is found in the pus of wounds and ulcers, and in that of abscesses, and the multitudes in which it exists in the latter case may be understood from the fact that Dr. Ogston, taking the average of a number of specimens, tells us they showed close on three million micrococci per cubic centimetre. Inject a drop of pus containing them and you will certainly cause abscesses to form. Destroy the organisms by boiling, or select pus devoid of them, and with proper precautions you will have no such result. Like many ferment organisms, these particular micrococci are at once aerobic and anaerobic, can multiply themselves either in presence of free oxygen or cut off from it. Their life, however, when exposed to oxygen is not a vigorous one, and when put to the test of artificial cultivation outside the living body, the slightest access of free oxygen to the fluids in which they are grown renders the results most uncertain. Having tried all manner of devices to achieve their cultivation, Dr. Ogston at last hit upon a method at once simple and ingenious. Taking a fresh egg, he drilled a minute hole through the shell at one end, and through it, by means of a slender needle, which he passed down to the other end of the egg, he injected a drop of pus containing these micrococci. Then covering the egg with antiseptic dressing, so as to prevent the access of any organisms from without, he maintained it at a suitable temperature. On opening it after a few weeks, he found that the micrococci had multiplied and spread themselves throughout the entire egg. A drop of its contents injected into another egg in the same manner would give rise to the same results, and a drop of the albumen thus artificially contaminated with the micrococcus, after many artificial cultivations, would give rise to its characteristic formation of pus. Of course, pus can be formed without its intervention, but when it is present the suppuration is much more abundant, and, what is all important, there alone will the pus set up fresh abscesses wherever a drop of it, or the pyogenic microbe with which it abounds, may be borne by the circulation.

But you will probably think that I have long enough assumed the connection of cause and effect as existing between these microbes and the diseases with which they are found associated, and that it is time that I should say something of the methods by which it can be proved that they really stand to each other in that relation. You are aware that microbes of various species may be found in the saliva and in the secretions of the bronchi and intestines, even where there is no disease, and there can be no doubt that after death these microbes make their way into the blood and tissues of the body, when the microscope often reveals them. It is not enough, therefore, to find bacteria or vibrios, or other microbes, in the fluids of the body, to enable you to say that they have had anything to do with a disease. To prove the relation of cause and effect between a specific microbe and a specific disease a much more rigorous method of demonstration must be adopted. You must not only show that the microbe is found associated with the disease, but that it is always associated with it. You must not content yourself with showing that by the inoculation of blood or serum containing the microbe the disease can be produced, but you must show that if the microbe be destroyed or removed the fluids are rendered harmless; and to complete the case you should be able to free the microbe by artificial cultivation from all contamination with the fluids of the disease, to grow it as a simple ferment outside the body, and to show that, thus purified, when introduced once more into the animal economy, it gives rise once more to the particular disease.

The process has been most exhaustively and satisfactorily worked out in the case of the *bacillus anthracis*, the organism of the splenic fever of cattle. That microbe is exceptionally large, and it was doubtless in consequence of this characteristic that it was the first to be discovered and have its importance as a disease factor recognised; but it is a noteworthy fact in connection with my text, [illegible] when the tempera- [illegible]

[illegible] mode of reproduc- [illegible]

[illegible] from which the [illegible] from a state [illegible] sufficiently [illegible] the calculus [illegible] not more than [illegible] drop of liquid is as much [illegible] of liquid as [illegible]. Freed thus from every [illegible] of splenic fever continue [illegible] and thus purified the different [illegible] and its germs can be verified [illegible]. The life of this [illegible] like that of other [illegible]. That of its germ or spore is as defiant as theirs of ordinary destructive agencies. It preserves its vitality for years, resists drying or moisture, cares nothing for compressed oxygen or absolute alcohol, and can defy a heat considerably above the boiling point. Now, it is a fact remarkably illustrative of the intimate natural connection between microbe life within and without the animal body that it has been shown by direct experiment that if the blood of an animal which has perished of splenic fever is mingled with earth (as where one is skinned on the field where it has perished), especially if the earth be moistened with manure water, the bacillus grows and multiplies itself, and gives rise to numerous corpuscle germs, which can be recovered by cultivation many months or years afterwards, and are still capable of giving rise to the disease. In fact, Pasteur has demonstrated that it is in this manner that the disease is perpetuated in those countries where it abounds, and has shown, in the most conclusive fashion, the important part played by the earth-worm in bringing to the surface spores of the microbe from the graves in which animals that have died of splenic fever have been buried.

And now let us glance at another microbe, the study of which has gone on along with that of the microbe of splenic fever, casting upon it a light which has led to the achievement of the most marvellous practical results. I refer to the microbe of fowl cholera. This is a minute micrococcus which, as I have already said, Toussaint, who originally succeeded in cultivating it outside the body, after a very elaborate experimental investigation, declares to be identical with the microbe of the acute septic disease which we have seen artificially produced in the rabbit. If he be correct —and certainly his facts look very strong—the genesis of fowl cholera is exactly similar to what takes place in the rabbit, only in this case the micrococcus is multiplied and freed from the other microbes, which in ordinary putrefactions struggle with it for life, by a process of natural instead of artificial cultivations on a peculiarly adapted soil. The microbe, according to Toussaint, exists among a host of others in ordinary putrefactions, and swallowed by the fowl in its food, when any accidental abrasion of mucous membrane exists, it inoculates itself upon the fowl, multiplies itself within its body, is excreted with its excrements, infects the food and pebbles swallowed by its neighbours, and in the course of a few cultivations finds itself in full purity and virulence exactly as we have seen it do under a series of artificial cultivations on [illegible] Now, the microbe of fowl cholera, unlike that of splenic fever, so far as its history is known, multiplies itself by fission [illegible] has never been shown to produce germs or spores. [illegible] this, for the yeast plant [illegible] —although, according to Rees, when cul[illegible] it alters its manner of multipl[illegible] spores. I have no doubt that you have [illegible] cholera in chick[illegible] oxygen, M. Pasteur succeeded [illegible] in an attenuated form [illegible] inoculated with [illegible] can be reduced to such [illegible] rise to only trifling local symp[illegible] this condition it exercises a specific influ[illegible] has been inoculated which protects it against [illegible] disease, in the same [illegible] vaccine lymph protects mankind [illegible] What I want to call your attention to is the [illegible] process, and the intelligent manner in which this [illegible] What I want to insist upon is [illegible] the all-importance of the study of [illegible] if we desire to appreciate or to con[illegible] and in order to illustrate this point we [illegible] yeast plant.

[illegible] researches undertaken for the purpose of [illegible] physiology of various alcoholic fer[illegible] that if you take any of the varieties [illegible] perfect purity, place them in a quantity [illegible] pure air, and allow them to exhaust [illegible] they grow, the fermentation ceases. [illegible] their vitality for a long time. [illegible] becomes altered, and their energy as [illegible] suppose that after all fermentation [illegible] a yeast under the conditions [illegible] taken on successive days and [illegible] will be set up, but, other [illegible] after each successive sowing [illegible] The vitality of the cells so treated [illegible] and it takes them longer [illegible] on which fermentation [illegible] but with proper treatment they may be preserved in life for a very long time, and will then be found to have undergone very remarkable alterations in their mode of growth. Years ago, when discussing the results thus obtained, Pasteur observed that the law thus discovered would probably be found to extend itself to all anaerobic ferments. What, then, could be more natural than that when he ascertained that the microbe of fowl cholera multiplied itself in chicken soup nearly as freely as yeast did in wort, he should conceive the idea of treating it in the same way, and so testing whether a similar change could not be wrought in its fermentative action? He did so, and found that so long as it was afforded fresh supplies of chicken soup it multiplied itself as yeast does under similar circumstances, unchanged, and after a hundred successive cultivations proved as virulent as at the first. But if you allow it to exhaust the element on which it lives, leaving it at the same time in contact with the oxygen of the air, a change occurs precisely analogous to that which Pasteur had discovered in the case of yeast similarly treated. Its vitality as a ferment gradually diminishes, and the virulence of its action when inoculated upon fowls every week becomes less and less marked. Now, in his yeast experiments, Pasteur had found the necessity of securing his microbe in a state of absolute purity. While its life is vigorous, its superior energy enables it to triumph over any parasites with which it may be contaminated, and to kill them or restrain their development by forcibly seizing upon the elements which they require for their growth. But when its vitality is weakened, if these parasites exist they come to the front and kill off the yeast. Now, we know that the living body is made up of living cells, and, when a ferment is introduced into it, then a contest for existence at once arises between them and it. Had Marix in the experiment I have referred to made use of yeast enfeebled by the treatment just described, I have no doubt he would have found that he could have injected much larger doses than he did without fatal results. In the struggle for life the weakened yeast would have gone to the wall, just as the fresh yeast did when an insufficient dose was set to work against the combined forces of all the blood globules and other cells of the body. Now, this is precisely what did occur when the microbe of fowl cholera, enfeebled by prolonged starvation in oxygen, was introduced into the circulation of healthy fowls. The energy of the organic cell-life within them was sufficient to achieve over it a victory more and more easy, precisely as it was less or more [illegible] as when infected in the ordinary way, fowls die or recover according as their natural forces are or are not sufficiently strong to overcome the dose of the microbe which has introduced itself into their system. And as it is found under circumstances of ordinary infection that the system of the animal which recovers has undergone some change which renders it unapt to contract the disease a second time, so in those which recovered from the attenuated virus it was found that a like effect had been produced.

Extending his researches to the microbe of splenic fever, Pasteur discovered that a similar course of treatment in its case produced similar results. It too became enfeebled or attenuated, but with much greater rapidity, and when thus attenuated its inoculation upon sheep or cattle produced precisely analogous effects. But in the case of this microbe there is an important difference, which greatly augments the facility with which we can avail ourselves of its attenuated form as a protective against the disease. As I have said, you can, by regulating the temperature of its cultivation, compel the microbe of splenic fever to multiply itself either by fission or spores. In order to secure the desired attenuation it is necessary that it should multiply itself by fission, and if, when attenuated to any required degree, it is allowed to produce its spores, these spores retain precisely the powers as ferment [illegible] which they have inherited from their attenuated parent cells, and months and probably years afterwards will reproduce their species with fermentative powers attenuated to the same degree. And what renders this fact the more remarkable is, that it is exactly in accord with another fact discovered by Pasteur in his investigation of the yeast plant—namely, that when submitted to a very prolonged process of starvation in contact with oxygen its cells underwent changes very similar to those [illegible] by Rees to mark its sporulation, and that, when then cultivated in fresh wort, the yeast resulting possessed characteristics altogether distinct from the species of microbe from which they had been proximately derived. Again, as the fermentative vigour of the attenuated yeast plant can be restored by cultivation under circumstances favourable to its growth, so the attenuated microbe of splenic fever cultivated on newly-born guinea pigs, or the attenuated microbe of fowl cholera cultivated on small birds, is rapidly reinstated in all its original destructiveness to animal life. In the course of these investigations other modes of curtailing these microbes of their powers have been discovered. Toussaint, for example, found that by heating blood containing the bacillus of splenic fever up to a certain point he so enfeebled those of the organism that survived that on inoculation the blood so treated sometimes gave rise to a mild protective form of the disease, similar to that which Pasteur had secured by his system. Toussaint's method was, however, uncertain. Sometimes the microbes were all killed, when no protection was afforded; sometimes they were not sufficiently scotched, when a fatal result ensued. Again, MM. Arloing, Cornevin, and Thomas have discovered that by injecting carefully-restricted doses of the microbe of the Maladie de Chabert (a disease for a long time confounded with splenic fever), direct into the blood current of cattle, precautions being taken to prevent all contamination of the solid tissues in the process, they can produce the same protective result. On the other hand, the smallest infection of these tissues with the organism may give rise to the disease in its worst form.

How are we to account for the difference? More than one theory has been advanced, but it is probably premature to generalise, for different disease ferments seem to act very differently under the same circumstances. Thus Chauveau found that by injecting vaccine into the circulation of the horse he produced a generalised eruption instead of the strictly local one produced by ordinary inoculation with the virus. Different disease microbes will doubtless be found to develop greater vitality in different fluids and tissues, precisely as different ferment microbes are known to thrive best in different media of cultivation. My object has been to trace the intimate connection which exists between the processes of fermentation and disease, but as yet I have said nothing of the products of fermentation in disease. That such products are formed there can be no doubt, but their production is complicated with so many other vital reactions, and their operation so masked by other vital phenomena that, so far, very little is known regarding the extent or nature of their action in disease. The microbes, multiplying themselves in the body by millions and tens of millions, as they are known to do, must materially interfere with the composition and aëration of the blood. By their size, or by the peculiarities of their growth, they may block up the capillary circulation in vital organs, and produce death by some mode altogether unconnected with the product of their fermentation. Thus the yeast injected in Marix's experiment deprived the blood of every trace of sugar, doubtless with the production of alcohol; but no alcohol was discovered in the analysis, and it probably played a very secondary part in the causation of death. That the microbes of disease may give rise to distinct ferment products outside the body is shown by the fact that the fluid in which the microbe of fowl cholera has been cultivated is impregnated with a new narcotic product, and that when freed from the microbe by filtration and injected into healthy fowls, this product gives rise to temporary symptoms of narcotism, exactly similar to those which in the natural disease constitute a very prominent feature. Certain of the microbes of putrefaction, too, in the course of their development outside the body give rise to an alkaloid—sepsine—to which I have already referred, which, as a poison, produces the same symptoms observed in certain forms of septic disease.

Did time permit I might adduce other examples of a similar kind, but it would serve little purpose; for, though the importance of the study of this phase of microbe life is now recognised, that study is as yet in its infancy. You will, however, with myself, be inclined to think that I have already trespassed upon your patience at too great length. I have by no means exhausted the subject, nor have I been able even to touch upon some very interesting points in connection with it. My object has been to trace in fuller detail than I have yet seen done the intimate connection between the processes of fermentation and disease, and to illustrate what has again and again been insisted on by Pasteur in France and Tyndall in this country, that to the right understanding of the nature and processes of the one the study of the nature and processes of the other is an indispensable requisite. I am fully aware that I have done but scanty justice to my theme, but we have considered together a number of the characteristics possessed in common by microbes of fermentation and disease. We have seen how organisms which habitually give rise to the process of fermentation may, when transferred to the interior of the living body, give rise to the phenomena of a specific, though artificial, disease. We have seen that the mixed ferment organisms of ordinary putrefaction, by a series of animal reagents, can be separated into their component species. We have seen in fowl cholera a disease, dependent on a ferment microbe, probably to be everywhere met with in ordinary putrefactions. We have seen how that microbe can be spontaneously separated from its fellows and brought to a state of wonderful purity and deadliness by cultivation within the animal body, and how when in this state transferred once more from a living to an artificial soil it again comports itself precisely like the ferment cell of ordinary yeast, multiplying itself by fission and producing a narcotic poison as that produces alcohol, becoming, like it, enfeebled by prolonged starvation in presence of oxygen, but capable, by proper treatment, of being once more revived into its full pristine activity. We have seen the bacillus of splenic fever with its natural *habitat* in a living soil, yet capable of life and multiplication in earth, and susceptible of artificial cultivation in yeast water and other organic solutions, manifesting the same enfeeblement as yeast under prolonged exposure to oxygen, and capable of restoration to its original virulence by analogous methods. We have seen how, inspired by the suggestive study of a fermentation, Lister thought out his antiseptic system, and Davaine first discovered that a microbe was the cause of a disease. We have seen by what obvious and intelligent steps Pasteur was led by the results of experiments on yeast plants to his process for attenuating the microbe of splenic fever, and his discovery of a preventative against a most formidable disease. Had time permitted I should have liked to have said something about the microbes described as associated with other diseases. I should especially have wished to refer to the proofs which Professor Villemin has adduced to show that tuberculosis is a disease of microbic origin—what different microbes have been said to have been discovered in connection with it, and how Toussaint appears at length to have discovered the right one, and has found it to increase in virulence under artificial cultivation. I should have liked to speak of the extraordinary and important results reported by M. Talamon in connection with diphtheria, which only require confirmation by independent observers to render that formidable scourge one of the most thoroughly understood of our diseases. I should have liked to point out the manner in which the whole subject has been shown to bear upon the mysteries of hydrophobia, these again upon the nature of the poison of snake-bites and the possibility of their cure, and that again upon the existence of an unsuspected poison in human saliva. One might, in fact, advert to all these and many more topics, pregnant with promise to the future of medicine and humanity, and yet leave the subject unexhausted, with much still to be said about the part played by microbes in fermentation, putrefaction, and disease.

VI.—*On the Present State of Opinion as to Animal Electricity.* By J. McGregor-Robertson, M.B., M.A., Muirhead Demonstrator of Physiology in the University of Glasgow.

[Read before the Society, 18th January, 1882.]

It was in 1786 that the theory of animal electricity had its birth, under circumstances of little apparent significance. The wife of Galvani, Professor of Anatomy and Physiology at Bologna, was engaged in the essentially domestic duty of preparing her husband's dinner, he being at the moment experimenting in the neighbourhood with a frictional electrical machine. It was observed that the frogs' legs, which Madame Galvani was preparing, contracted spasmodically when a spark was emitted from the machine, if a metallic substance happened at the moment to touch them. Galvani supposed the convulsions to be due to electrical conditions of the air, and, to verify this, suspended several frogs' legs by copper hooks from the iron balcony of his house. When the frogs were blown against the railing by the wind he observed the contractions. He concluded the contractions to be due to an electrical current in the frogs themselves, which stimulated the muscles as soon as a circuit had been established by means of the metallic conductors. He showed that, by connecting the nerves of the lumbar region of the frog with the muscles of the thigh by means of an arc composed of two dissimilar metals, a contraction was produced on each contact. These results were communicated to the Institute of Bologna in 1791, in a paper entitled "Aloysii Galvani de viribus Electricitatis in motu musculari Commentarius." Alexander Volta, Professor of Physics at Pavia, proceeded to investigate the subject, and the results of his examination led him to conclude that the cause of the convulsions was not an inherent electrical current but the contact with the moist tissues of two dissimilar metals. Aldini, nephew of Galvani, supported the natural current theory, and a new fact was added to Galvani's argument—viz., that no metal was necessary to produce the contraction, all that was needed being the establishment of a circuit between nerve and muscle, which was obtained by allowing the nerve to fall, in a particular manner, on the muscle to which it was attached. Volta's discovery of the voltaic pile seemed for a time an unanswerable argument in favour of his view. Aldini continued to defend Galvani's results, and travelled through England and France demonstrating his experiments, receiving, as one return, a gold medal from Guy's Hospital, London, in 1803. In spite of this, however, the idea of animal electricity did not find any vigorous support till, in 1827, Nobili, employing a galvanometer constructed on the astatic principle, showed a current in the frog passing from the feet to the head. In 1841 Professor Matteucci, of Pisa, constructed what he called a muscular pile, by arranging end to end a number of frogs' thighs, from which a pretty strong current, passing upwards in the thigh, was obtained. In the same year Professor Emil du Bois Reymond proceeded thoroughly to investigate the truth or falsity of the current theory, and succeeded in placing it on a satisfactory and exact basis. For the purpose of indicating the current he used a reflecting galvanometer of extreme sensibility, whose oscillations were controlled by a magnet in its vicinity. The very sensitiveness of the galvanometer is, however, one of its chief sources of error. If the ends of the galvanometer wires be connected with two wires, say of copper, the ends of which are immersed in a conducting fluid, a deflection of the needle at once indicates a powerful current, because the two wires are not in an absolutely similar electrical state; or if the wires be directly connected with the tissue to be examined, another powerful deflection occurs, because electricity is evolved at the point of contact of the wires and the moist tissue. Du Bois, at the outset, therefore, found it necessary to devise some sort of conductor which would not itself generate a current. He employed as electrodes two troughs made of zinc, and insulated by vulcanite. The inner surface of the trough is carefully amalgamated, and the outer surface lacquered, Fig. 1. Into the trough is poured, as a conducting fluid, a saturated solution of pure sulphate of zinc. Pads formed of several folds of blotting paper, saturated with the zinc solution, are next arranged in the troughs, in such a fashion that part of the pad dips into the trough and part projects over its lip, the projecting part being terminated by a sharp perpendicular section *b*. If now the tissue were placed on this conductor, the solution of zinc would attack it and vitiate any result. There is still, therefore, required something which shall protect the muscle or other substance from the chemical action of the zinc, and still act as a conductor of any current that may be present. This is supplied by a small thin plate of moulder's clay, P, moistened with a $\frac{1}{2}$ to 1 % sol. of common salt, which is laid on the blotting paper. A bent plate of gutta-percha *s*, fastened to the trough by an elastic band, keeps the blotting paper in position. These are Du Bois Reymond's non-polarizable electrodes. If, now, these troughs, having been prepared with sufficient care, are brought into connection with the galvanometer, the needle should, by remaining stationary, show no signs of current. The tissue to be examined is now arranged so that part of it is touching the clay pad of one electrode and part the clay of the other. If a current be present it is indicated by a movement of the beam of light reflected from the mirror of the galvanometer.

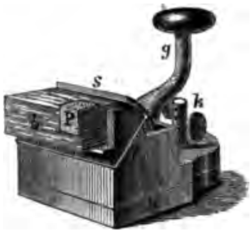


FIG. 1.

To determine in what direction that current may be, a preliminary observation is necessary. To one wire of the galvanometer a piece of zinc is bound, and to the other a piece of copper. The two being placed in circuit, a current is produced, and the beam of light moves in a particular direction. The copper being positive to the zinc, you can find in which direction the beam of light will move if a particular wire is the positive. The non-polarizable electrode to which this wire is connected is carefully noted, and one can then always tell in which direction the needle must swing if this be the positive electrode. Into the circuit of the electrode and galvanometer is placed a small resistance box or shunt, graduated for the particular galvanometer used. It is so interposed that one of the brass plugs may be placed in one of four different positions. If in one, the current is short-circuited, and none can pass to the galvanometer; if in another, a 10th part of the total amount of current is allowed to pass; or in other positions, 100th or 1000th—the remainder being returned to the electrodes. With the aid of such an arrangement, Du Bois Reymond obtained a current from the inactive muscle of the frog equal to from 0·035 to 0·075 of a Daniel. This maximum effect was obtained when a muscle of the frog, one with as parallel fibres as possible (semimembranosus, or gracilis), was removed from the body, and so placed on the electrodes that one clay pad touched the centre of the longitudinal surface and the other the centre of a carefully-made transverse section. This current is directed *in* the muscle from the transverse section towards the longitudinal surface—that is to say, it passes *out of* the muscle by the longitudinal surface and returns to the transverse section. The rule so formulated is—*The longitudinal surface is positive to the transverse section, which is negative.* A point in the equator of the longitudinal surface is most positive, the axis of the transverse section is most negative. As you proceed from the equator towards either end of the surface the positivity diminishes, and as you proceed from the axis of the section towards the circumference the negativity diminishes. To put this in another way—*On the longitudinal surface, a point at a distance from the equator is negative to a point nearer to it; on the transverse section, a point at a distance from the axis is positive to a point nearer to it.* If two points are taken on the longitudinal surface of a regularly-formed muscle, one on each side of the equator, and both equidistant from it, these two points are iso-electrical as regards one another, and show no current, and similarly with two points on the cross section equidistant from the axis. Fresh cross sections may be made, and fresh longitudinal surfaces may be formed, still the muscle cylinder exhibits the same phenomena, and that whether the surfaces have been formed by cutting, heating, action of acids, or simply by drying of the exposed surface. In the last case, the layer of dead tissue on the surface acts as an indifferent conductor, and leads the current produced in the living portions beneath it.

In the case where the cross section has been made oblique, Du Bois showed that the greatest positive tension is towards the obtuse angle, the most negative point towards the acute angle—*i.e.*, a point in the neighbourhood of the obtuse angle is positive to a point in the neighbourhood of the acute angle, even though both were equidistant from the equator. These have been called "inclination currents" ("neigungsströme"). The relative electrical condition of different points is best investigated by a modification of the non-polarized electrodes made by Du Bois himself. A flattened tube of glass, *r* (fig. 2), contains a slip of amalgamated zinc.

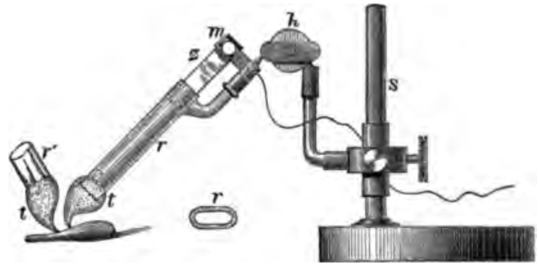


FIG. 2.

The end of the tube is closed by a moistened piece of clay, the part projecting from the tube being pressed to a point *t*, and the tube is then filled with zinc solution. The zinc is fastened to a brass support, to which a wire is led. (See Diagram.) The fine clay points can then be placed on any desired part of the muscle. As the muscle preparation slowly dies, the amount of current diminishes, till, on the advent of rigor, it disappears. In regard to temperature, freezing and a high temperature also abolish it, but with moderate degrees of heat it increases.

Differences of temperature produce specially strong currents,* a warmer part being positive to a colder, the difference between the two connected points being alone influential, and the condition of the parts lying between being unimportant.

A method of accurately determining the amount of current obtained from muscle or other tissue was devised by Poggendorff. An improved form of the arrangement, by Du Bois Reymond, is shown on the accompanying diagram, Fig. 3.

The idea of the arrangement is to send through the galvanometer, B, the maximum strength of current obtained from the tissue, M, placed on the electrodes, T, and then to send from a Daniel's cell, K, *but in an opposite direction*, a portion of current sufficient to counterbalance the tissue current. The needle is thus subjected to two forces, equal in amount but opposite in direction, and it therefore swings back to zero, its remaining there indicating the balance of the two forces. By the arrangement the amount of current from the Daniel employed can be regulated at will, and can be exactly estimated. It therefore becomes a measure of the force it counteracts. This is called the compensation method.

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* Hermann, Handbuch der Physiologie. 1879. Bd. I. Th.I. S.196.

From the Daniel, K, wires proceed to the binding screw *a* and *b* at each end of the long compensator, which consists of a stretch of platinum wire of uniform thickness. A slider, bearing a platinum point, *c*, to make contact, is movable up and down the wire. From one binding screw of the compensator a wire proceeds to one terminal of the galvanometer, through a commutator, C, the other terminal being connected with the slider also through the commutator.

The Daniel's cell and the platinum wire of the compensator may be considered as the main circuit, and the galvanometer circuit as a branch from it. The current from the Daniel may, therefore, pass straight along the compensator and back to the cell, or a portion may start from the binding screw *a* through the galvanometer, and regain the compensator by the connection with the slider at *c*. The strength of this portion will depend on the resistance in the branch circuit. By varying the position of the slider the relative amounts of resistance in the main circuit and its branch are altered, and so a stronger or weaker current can be sent through the galvanometer from the Daniel, according as the slide is nearer *b* or *a*.

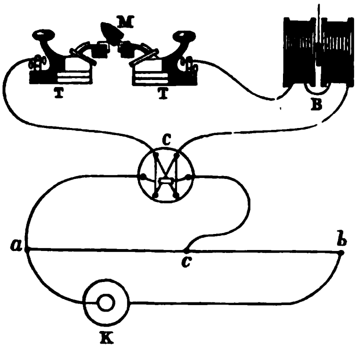

Fig. 3.

The distance between *a* and *c* is read off by means of a millemetre scale placed beneath the platinum wire, and since the wire is regular throughout the distance, *a c* is a measure of the resistance, and ∴ a measure of the amount of Daniel sent through the galvanometer. By means of the commutator the Daniel current can be sent through the galvanometer in one direction or another. Thus a current from the Daniel, whose amount can be measured, can be sent through the galvanometer equal in amount and opposite in direction to the current from the muscle, the one compensating for the other.

The observations made by Du Bois, already mentioned, are seen in resting muscle. If the muscle has been prepared with the nerve attached, and if the nerve be stimulated so as to tetanise the muscle, a marked diminution in the muscle current is observed, and the needle swings back a considerable distance. Sometimes the diminution = 40 % of the original current. This is called the negative variation of the muscle current. If the tetanus be continued the diminution becomes less marked. On its cessation the needle swings back, but never quite up to its original position when the current of the resting muscle affected it.

Du Bois explained these facts by supposing that a muscle was formed of a number of dipolar or tripolar electro-motive molecules suspended in a conducting fluid, their positive sides towards the surface, negative towards the transverse section. He thought the negative variation was due to a rearrangement of the molecules.

In the accompanying figure M shows the dipolar, and L the tripolar arrangement—the darkly shaded portions of the circles representing the negative parts.

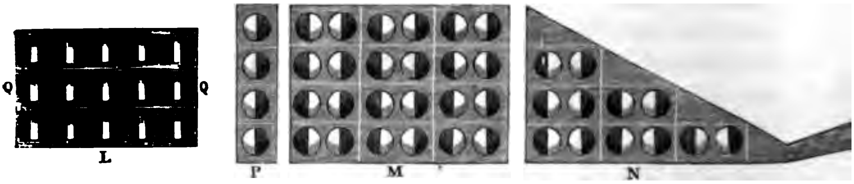

FIG. 4.

Du Bois, in his earlier experiments, thought he obtained a current from an uninjured muscle—*i.e.*, from one whose longitudinal and transverse sections were natural, and not artificially produced. Later, however, he discovered that, if special precautions had been taken not in the slightest degree to injure the muscle, no stream was obtained in the resting state, though on the production of tetanus the usual negative variation was observed. If a stream were obtained when the muscle was at rest it was seriously diminished in amount, and might even be in a direction quite contrary to the usual. Du Bois explained this by supposing that, in the uninjured muscle, the tendinous end, which is the natural transverse surface, contains a layer of electro-motive molecules, with their poles reversed, so that their positive surface is towards the transverse section. This layer he called the Parelectronomic layer, and on removing it by making an artificial cross section, the full muscle current is obtained.

This layer with reversed poles is represented in the figure by P, while N represents the arrangement in an oblique section, giving rise to the "inclination currents."

These views of Du Bois have found an opponent in Professor L. Hermann, of Zürich, who concludes, from many carefully-made observations, that in the absolutely uninjured frog's muscle there is no current. He believes that the current is the result of injury, causing death of a small part of the muscular fibre, and so producing difference of potential. In support of his views he adduces many arguments and observations. There are few muscles which can be prepared without some slight injury, since in the majority of cases some fibres pass out from the muscle to be attached to the skin, and in stripping off the skin these fibres are torn, and an artificial cross section produced. Du Bois, therefore, tried to obtain the current from the muscle in situ—*i.e.*, without stripping off the skin—but found in the frog strong skin currents directed from without inwards, which interfered with the experiment. These skin currents are abolished by corroding the skin, *e.g.*, with saturated salt solution, and, when this has been done, the ordinary muscle stream is obtained. Hermann objected that the corrosive agent not only set aside the skin current but permeated to the muscle itself, and acted on it, producing chemically a transverse section, so that the current obtained was not from the uninjured but from the injured muscle. In fishes, which exhibit no stream current, and where, therefore, corrosion of the skin is unnecessary, no muscle current is obtained when the fish is curarized to render motion impossible. Hermann also points to the fact, shown by Engelmann, that the heart, which can be laid bare without injuring its fibres, shows no resting current, though it shows a negative variation. Hermann found that even the secretion of the skin of the frog applied to the muscle produced by its action a current, indicating injury of the fibres. Engelmann also showed that a section produced subcutaneously on a living muscle gave rise to a current, which, however, disappeared on the repair of the injury.

From such facts Hermann concludes that *striated muscle in a perfectly uninjured condition is absolutely streamless*, and that the muscle stream is connected with the existence of an artificial transverse section. According to him, a muscular fibre exhibits a current only when one part of it is dying and the other part is still living protoplasm, but, as soon as the whole fibre is dead, the stream disappears. In order to verify this view, Hermann devised an apparatus called the "Fall Rheotom."

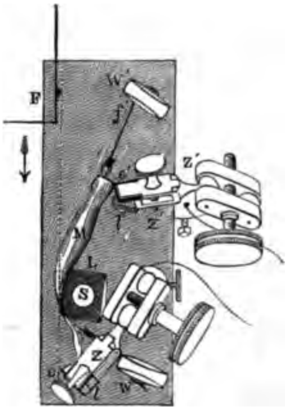

FIG. 5.

By means of a falling weight, F (Fig. 5), shod with shagreen, part of the aponeurosis of the Tendo Achilles of a gastrocnemius, M, is stripped off, and, almost instantaneously with this, the galvanometer circuit is closed, and, in a very short time thereafter, opened by the same weight. By this means, and through a compensation arrangement, the amount of current obtained from the muscle immediately after injury is measured. A second similar observation is immediately made on the same muscle now injured. Hermann found that there was a deflection of the needle obtained from the muscle immediately on its injury, but the second observation gave a very much greater deflection, showing that after the injury the current took a little time to develop. This time, in the gastrocnemius of the frog, Hermann gives as $\frac{1}{400}$ of a second, that is to say the electrical effect is not immediate, but takes $\frac{1}{400}$ of a second to develop after injury. Hermann admits the occurrence of negative variation in the *injured* muscle, but, since he denies the existence of a stream in an absolutely uninjured resting muscle, he cannot admit a negative variation in the *uninjured* muscle. Still, on stimulating an uninjured muscle which exhibits no current, a deflection of the needle is observed. This current, obtained in quite normal muscle by stimulation, Hermann calls the "action stream," which passes in the muscle from longitudinal to transverse surface. The time of occurrence of this "action stream" or "negative variation" has been fixed by Helmholtz and V. Bezold as preceding the contraction of the muscle.

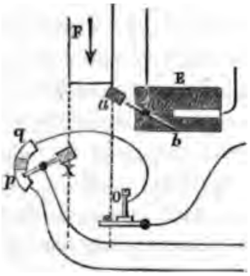

FIG. 6.

This diagram shows part of the arrangement of the "Fall Rheotom." The falling weight, F, having injured the muscle in the way shown in Fig. 5, is then made to strike against keys *a*, X, O, by which the galvanometer circuit can be closed and then opened, or other effects produced speedily the one after the other.

Bernstein continued these researches by means of an instrument called the repeating rheotom, and, in a muscle giving no stream while at rest, he obtained by stimulation not only a single but a double deflection of the needle, the first in the negative, the second in the positive direction. This double variation was found to propagate itself through the muscle at the same rate as the wave of excitation. The "negative variation" then, or "action stream," is associated with the passage through the muscle of a wave of excitation. During the passage of the wave each irritated muscle point becomes negative to a point at rest, that is, when the wave reaches a point it becomes negative to another point beyond the wave, and when the wave has passed the first point it returns to a positive condition in relation to the part of the muscle to which the wave has now passed. The one point being first negative and then positive, explains the double deflection. In a muscle with an artificial cross section, the second phase of the double deflection disappears, and thus the negative variation is accounted for. In a totally tetanized muscle, in which the stimuli pass so rapidly that the irritation wave is everywhere present, no "action stream" is found.

Such is a general statement of the facts offered by Du Bois and Hermann for and against the theory of an electrical current in normal living muscle. If Du Bois were correct it was natural to suppose that the muscles of living man would show a considerable current, and a negative variation on voluntary contraction. But Du Bois completely failed to detect a current from living muscles of man at rest. If, however, one dips both hands into vulcanite troughs filled with salt solution and connected with the galvanometer, and then voluntarily contracts the muscles of one arm, the needle is deflected to one side; if the muscles of the opposite arm are contracted, the needle swings in the opposite direction. This Du Bois accounted a negative variation. This Hermann declares to be no muscle current at all, but to be due to a secretion stream directed from without inwards on the irritated side—a skin current. In his experiments, stimulation produced sweating and the electric current, but when Atropia was given both disappeared. "A man," he says "paralysed by Curare would show the Du Bois current in spite of the absence of contraction, and a man under the influence of Atropia would not show the current, in spite of the occurrence of contraction."* That is, in the former case, stimulation could not produce contraction on account of the Curare, but it would produce sweating, and a current—a secretion stream—would appear; in the latter case it would produce contraction, but on account of the Atropia there could be no sweating and there would be, therefore, no current.

To the Du Bois theory of polar particles, or the pre-existence theory, Hermann, therefore, opposes what he calls a difference theory *(alterations theorie)*, because it refers all electromotive effects of muscle to two kinds of physiological change. The first part of the theory is that *the dying portion of the substance behaves itself negatively to the living*, and the electromotive force has its seat in the demarcation zone between the living and the dying. To this he adds a rider that not only death but *irritation as well causes the affected substance to become negative to the unaffected portion.*

Nerves exhibit electrical phenomena exactly comparable to those of muscle, positive longitudinal surface and negative transverse section.

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* Hermann Handbuch der Phys. Bd. I., Th. I. S. 224 u. 225.

A pulsating frog's heart, a slice of whose apex has been cut off so as to lay a longitudinal surface and a transverse section on the electrodes, also exhibits an electrical current, and a so-called "negative variation."

It is not my purpose to offer any criticism of the facts and arguments of which I have tried to give a concise account. In the face of not one but two Goliaths like Du Bois Reymond and Hermann, I should with less excuse be rasher than David to seek an entrance into the fray. But that electricity is, in quite normal circumstances, developed to a surprising extent in animal tissues is conclusively shown by the phenomena of the electrical fishes, the Torpedo, Gymnotus Electricus, and others. In these, of course, it proceeds from an organ specially adapted, and is designed to meet the requirements of the animal, and for defence. But it affords a strong *a priori* ground for believing that at least hints of what attains great development in some animals may be found in others, for whom its development would be valueless.

VII.—*An Inquiry into the Prevalence of Small-pox in Kilmarnock in the Last Century.* By JOHN C. M'VAIL, M.D., Kilmarnock.*

[Read before the Society, 1st February, 1882.]

THE historian of the social life of the nineteenth century will probably devote a chapter to the description of a phenomenon to which he may have some difficulty in giving a name. He may say that it flourished chiefly in the decade through which we have just passed, and that it consisted of a peculiar social craze or mania, the chief symptom of which consisted in a strong tendency on the part of those affected to unite themselves into societies for the purpose of abolishing certain well-established and approved customs and procedures. The only essential qualities in the objects to be crusaded against seemed to be, he might say, that, in the opinion of those most intimately acquainted with the matter, they were of great benefit to the public health and welfare, and ought not to be interfered with. These societies are at present best known to the public by the prefix "Anti," the three chief being the Anti-Vivisection Society, the Anti-Contagious Diseases Acts Society, and the Anti-Vaccination Society. How this social malady can be cured is not very obvious. But I am quite sure of this, that if the class of sufferers termed (owing to their symptoms, for a pathological nomenclature is not yet attainable in mental disorders) Anti-Vaccinationists, could have themselves placed in an asylum called up from the past by some magic wand, and consisting of the town of Kilmarnock as it was in the last century, a very short residence there would entirely cure them of their disease.

In the beginning of the year 1728, the schoolmaster of Kilmarnock, who seems to have been a man considerably in advance of his time, determined to keep a register of mortality for his parish, and the result of his decision is a beautifully-written old volume, which begins as follows:—

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* For much valuable aid in various matters connected with the preparation of this paper I am indebted to Mr. James Rose, Registrar of Kilmarnock.

> "Mr. Patrick Paisley, and Mr. Lawrence Hill, Ministers, "March, 1728. This register is begun by Mr. Robert Montgomerie, Schoolmaster in Kilmarnock, and Session-Clerk. He "having begun one of the same kind before, anno 1705, which was "carried on for some yeirs, and afterwards Lost when it was "committed to another hand to keep.
>
> "RO. MONTGOMERIE."

Besides giving the total annual births, the register consists of a statement of the date, name and designation, age, and cause of death, of all who died in the parish of Kilmarnock, from March 1st, 1728, to March 1st, 1764. Why it ends so abruptly after these thirty-six years we do not know. Probably the old schoolmaster, whose hand had been getting gradually more unsteady as he penned the solemn record of so many deaths, at last himself went over to the majority, and no one seems to have taken up his well-worn quill to register the fact.*

The records of these thirty-six years are in every respect interesting, and in some points important. The population of Kilmarnock in 1763 is said to have been nearly 5,000. During the following 29 years it increased at the rate of about 64 per annum.† Supposing that during the period under consideration the annual increase were 45, the average population of the thirty-six years would not be more than 4,200. The average number of births per annum was 134. Now, the number of births since 1855 (the date of introduction of registration) has been 48 per annum to each 1,000 of the population. Calculated by this standard, the mean population in the thirty-six years would be 3,350. I will take 4,200, however, as being the correct number, so as to avoid the possibility of exaggerating the mortality from small-pox.

The total deaths in the period in question were 3,860, or at the rate of 24·36 per 1,000 per annum—fully 1 per 1,000 per annum above the average of the past twenty-five years. If the population were only 3,350, the death-rate would be 32 per 1,000 per annum.

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* A more careful examination of the orthography and penmanship of the record shows that there have been two, or perhaps three, successive compilers. Robert Montgomerie's share in it ceases at the end of May, 1736. His death, however, is not registered. Possibly he left the district at this time.

† M'Kay's History of Kilmarnock, 4th edition, foot-note to p. 342.

The causes of death are shown in Table I., in which I have adopted the orthography of the old session-clerk.

TABLE I.

Mortality Table, 1728-1764, in groups of Six Years.

DISEASE.	1728-34.	1734-40.	1740-46.	1746-52.	1752-58.	1758-64.	
Decay, - - - - -	190	159	135	132	141	158	915
Age, - - - - -	88	95	91	97	131	123	625
Small-pox, - - -	111	67	139	95	133	76	622
Fever, - - - -	99	80	96	88	95	87	545
Bowel-hive, - - -	33	46	35	48	49	63	274
Kinkhost or Cinkough, -	14	47	1	12	11	31	116
Closing, - - - - -	...	5	29	30	33	9	106
Measles, - - -	1	11	18	52	4	7	93
Flux, - - - - -	11	17	53	6	1	7	95
Childbed, - - -	11	4	4	10	16	14	59
Teething, - - -	12	12	4	6	5	16	55
Suddenly and Hastily, -	4	5	9	2	4	5	29
Consumption, - -	2	...	...	3	...	20	25
Gravel, - - - - -	8	5	3	3	2	1	22
Dropsie, Hydropsie, and Swelling, - - -	6	2	2	5	4	3	22
Palsie, - - - - -	4	4	3	5	...	3	19
Colick, - - - - -	8	1	1	3	4	2	19
Tympany, - - -	2	2	4	2	6	1	17
Vomiting, - - -	12	2	...	...	...	...	14
Pleurisy and Stiches, -	1	2	1	1	5	2	12
King's Evil, Scrofula, and Cruels, - - -	5	...	3	...	...	2	10
Asthma, - - -	2	4	2	1	...	1	10
Gout, - - - - -	1	5	4	...	...	...	10
Cancer, - - - - -	2	1	1	1	1	1	7
6 each from Stoping and Purging, - - - - - - - -							12
5 ,, Fits and Convulsions, Accident, "Perished," - -							15
3 ,, Drowning, Lethargie, Scurvy, Rheumatism, and Rickets,							15
2 ,, Jaundice, Infancy, Apoplexy, Stone-cuting, Grief, Inflammation, - - - - - - - - -							12
1 ,, Broken Leg, Cholera, Cold, Ulcer, Overlaid, Mortification, Hystirick, Poison, Gangren, Spina Ventosa, Self-murder, Worm Fever, Universal Gout, Blabs, Ague, Weakness, Bowel-ricket, - - - - - -							17
Disease Unknown (about), - -							68
Total, - - - -							3,860

The flesh of Kilmarnock seems to have been heir to about 60 ills, and of these 4 are credited with fully two-thirds of the total deaths. At the head of the list is decay, with 915 deaths. What decay included it is difficult to say. That senility was not a necessary element is shown by the fact that deaths at the ages of one and two years are attributed to it. The term probably embraces nearly all chronic diseases causing emaciation and debility—among which, of course, consumption is the chief. The second disease is age, which, with its 625 deaths, has formed a convenient class for nearly all who lived over 70 years, and for a large number between 60 and 70 years. Passing over small-pox in the meantime, fever is responsible for 545 deaths. The town then, as now, was built on low-lying ground, by the side of a stream so small as to be nearly dry in summer, and quite insufficient for carrying off the impurities for which it would be the receptacle. The term seems to include scarlet fever, as it is not mentioned elsewhere, and also, perhaps, many cases of acute pneumonia, and other diseases running a rapid and febrile course. Bowel-hive is responsible for 273 deaths. The medical nomenclature of diseases in one generation may be said to be the popular nomenclature in the next. The bowel-hive of the doctors of the last century is now one of the most popular of children's diseases, and there is no mother worthy of the name who cannot tell all its symptoms and most of its treatment. It may be said to include most diseases of the stomach and bowels in infancy, and to be accountable for a very large number of the deaths during teething, and generally under three years of age. Kinkhost, or cinkough, stands next, with 116 deaths. Its leading symptom—the "kink" following the "host"—was so unmistakable, that its figures are in all likelihood quite correct. Closing (106 deaths) is the old name for croup. It was epidemic in 1745-6 (24 deaths) and 1746-7 (13 deaths). Previously to 1744 it is only once mentioned, but from that year onwards it figures regularly, with an annual average of 5 deaths. This sudden appearance of a new disease perhaps means the advent to the village of a new doctor, with the newest names, or else signifies an advance in the knowledge of the already-settled practitioners. The same may be said of consumption, which, curiously enough, is mentioned in the first year of the register, but does not turn up again for 19 years; and of its 25 deaths, 15 occurred in the last year—1763-4. Following closing, comes measles, of whose 93 deaths 52 occurred in one year—the next largest epidemics causing 14 and 11 fatalities respectively. Flux also caused 93 deaths, and probably means diarrhœa and dysentery (usually called bloody flux)—the latter a disease very well known in Kilmarnock even thirty or forty years ago, but one which promises to become an extinct species very soon. Childbed is accountable for [illegible] deaths. The small range of the numbers for each year—the highest being [illegible]—seems to show an absence of epidemic puerperal disease, and the high general average of mortality is likely to have been due to bad midwifery practice, and specially to the want of the "howdie." Teething caused 55 deaths, and [illegible] died "suddenly" or "hastily"—this number doubtless including sudden deaths from heart disease and apoplexy. Three deaths from lethargy may also have been due to apoplexy. I have already referred to the [illegible] deaths from consumption. Twenty died from gravel. In connection with this, observe that 2 deaths resulted from "stone cutting" in [illegible], so that lithotomy seems to have been occasionally performed. I have heard Dr. G. H. B. Macleod say that for many years the majority of cases of lithotomy in the Glasgow Royal Infirmary came from Kilmarnock and its neighbourhood. Calculus is certainly not exceptionally common now, the change being perhaps due to the substitution of a gravitation water-supply for that of the old surface wells. Dr. Borland informs me that he has heard his father say that when any serious operation, such as stone-cutting, had to be performed, surgeons came from Glasgow usually in a "carriage-and-pair," and by way of Mearns Moor, and almost invariably on a Sunday. The event was looked on as of great general importance—crowds watched the arrival of the equipage and its mysterious inmates, and prayers were publicly offered in the churches for the success of the operation. Twenty deaths were owing to diseases variously named dropsie, hydropsie, and swelling, and 19 to palsie. Nineteen deaths from colick and 17 from tympany, may represent enteritis and peritonitis, and perhaps a few cases of enteric fever—all these being accompanied by abdominal pain and flatulence. Fourteen deaths from vomiting, 12 from pleurisy or "stiches" (so named owing to the stitch-like character of the pain), 10 from king's evil, scrofula, and cruels united; 10 each from asthma and gout, and 7 from cancer, complete the principal figures. Gout is practically unknown now in Kilmarnock. Whether the home-brewed ale, or "caup yill," in which the glovers and wabsters of the old town delighted, was a beverage strong enough to bring on so aristocratic a complaint is a question I cannot answer. Certain it is that brewing was a common occupation, the designation "maltster" being by no means rare in the register.

The names of the remaining diseases, in most cases, explain themselves. "Stoping" was constipation, or ileus. The more interesting names are grief, cholera, hystirick, spina ventosa, self-murder, universal gout (or acute rheumatism), blabs, weakness, and bowel-ricket. Blabs probably meant chicken-pox, which used to be called "blab pox;" and the fact that it caused only one death in the thirty-six years rather confirms this view. Bowel-ricket meant, I believe, severe abdominal pain. Leaving this part of the subject with the remark that the whole register forms a rich mine of antiquarian lore, I turn now to the subject proper of the paper.

There can be no doubt but that small-pox caused more deaths, by a long way, than any other disease in old Kilmarnock. It is true that decay and age come before it in the list; but, as I have already pointed out, decay must include a great variety of diseases, and under the heading of age are placed, besides a number of deaths between the ages of 60 and 70, nearly all illnesses which proved fatal in those over 70 years—the old session-clerk evidently being a devout believer in the law which limits man's natural existence to three-score years and ten. Table II. may assist us in forming a mental picture as to the prevalence of small-pox in these old times. You will observe that epidemics occurred in 1728-9, 1733, 1736, 1740, 1744-5, 1749-50, 1754, 1757-8, and 1762—in all, nine epidemics in thirty-six years. In the intervals, the town was almost totally free from the disease. The average length of time between two epidemics was fully four years. They came with terrible regularity. If one or two were a little before their time, as in 1736 and 1740, the next were somewhat delayed, as in 1745 and 1750. The number of deaths varied from 45 to 95. You will notice that, on the whole, the extent of the epidemic corresponds—though not, of course, exactly—with the length of interval between the epidemics. Thus, the three largest (1754, 1749-50, and 1744-5) occurred after intervals of 4½ to 5 years; while previous to one of the mildest (1757-8) only 3 years and 2 months had elapsed. In 1733, however, there were only 45 deaths after a period of nearly 4½ years.

The epidemic of 1728 began on May 11th by a death in Beansburn, a hamlet on the outskirts of the town, and near the castle of the old barons of Kilmarnock. The next was on June 25th, in the same family; and the virulence of the disease came to a crisis in November, when, in a total of 23 deaths for the month, 17 were due to small-pox. It then gradually died out, ending with three

TABLE [illegible]

Deaths from Small-pox, [illegible]

Year.		Total Deaths.	Age in Years at Death.							[illegible]
			Under 1.	1.	2.	3.	4.	5.	6 and Upwards.	
May 11th to Jan. 29th	1728 1729	[illegible]	7	14	22	14	9	5	1 each aged 6, 11, 14, 22.	
	1730									
	1731									
	1732									
Jan. 4th to Aug. 2nd	1733	[illegible]	[illegible]	[illegible]	[illegible]	1	4		1 aged 7.	
	1734									
	1735									
July 14th to Dec. 30th	1736	[illegible]	12	21	20	[illegible]	[illegible]	1	3 aged 6, 1 aged 10	
	1737									
	1738									
	1739									
Feb. 25th to Aug. 3rd	1740	66	17	21	[illegible]	14	2	2	1 aged 6, 1 aged 8	1
	1741								...	...
	1742								...	...
	1743								...	
Aug. 4th to May 17th	1744 1745	74	[illegible]	13	19	11	10	2	1 each aged 6, 7, 9.	1
June 9th to Dec. 29th	1746	8	3	2	1	1			1 aged 6.	
	1747								...	
	1748	2			1	1			...	
Oct. 30th to Mar. 15th	1749 1750	84	12	17	22	15	12		3 aged 6, 1 each aged 7 and 21.	1
	1751	1				1	...		...	
	1752								...	
	1753	1	1				...		...	
March 1st to Oct. 3rd	1754	95	23	25	15	15	10	5	2 aged 7.	
	1755	...		...			...	...	...	...
	1756		...	...	...	...	...	...	...	
March 15th to Sept. 5th	1757 1758	46	11	10	13	6	4	1	...	2
	1759				...	...	...	...	...	...
	1760		...				...	...	...	...
	1761			...		...	...	...	...	...
March 5th to Aug. 30th,	1762	66	7	15	10	9	10	8	2 aged 6, 1 each aged 9 and 20.	3
	1763	2	..	...	1	...	...	..	1 aged 26.	...
Totals.		622	118	146	136	101	62	23	27	9

deaths in February. The second began in January, 1733, and ended on August 2nd, causing 45 deaths. There had been an interval of barely 4½ years since the last time. But in fully three years again the disease appeared—in July, 1736—and culminated in September, in which 23 deaths were due to it, among 30 from all causes; the total result being 66 deaths during the epidemic. It again appeared in February, 1740, and extended through the summer, ending on August 3rd, after having caused 66 deaths. The year ending February 28th, 1744, had been a very healthy one, only 55 deaths having occurred from all causes, or at the rate of 12 per 1,000 per annum. But, in the following August, pox again showed itself, and wrought deadly havoc throughout the winter, causing 74 deaths, of which 31 took place in January. It again raged from October, 1749, till March, 1750, causing 84 deaths, of which also 31 were in January. In the spring of 1754 the most severe of all the epidemics broke out, culminating in July and August, in which months there were respectively 39 and 33 deaths, in totals of 47 and 39 from all causes. The total mortality of the epidemic was 95. Two years and a-half after its close, another began; but the harvest was not ready for the sickle. The interval had been too short, and the outbreak never attained great violence, though it lingered on for the unprecedentedly long period of two years, causing 45 deaths in all. But in four years more a new generation of children had arisen, and 66 of these succumbed to the destroyer. Between these various epidemics, a few occasional cases occurred, amounting to 14 in the thirty-six years.

As showing the severity of the scourge, I may state that, in 7 of the 9 epidemics, the year's death-rate was actually higher than the birth-rate—in one year to the extent of 72 per cent. The figures are given in Table III.

TABLE III.

Epidemic Years in which the Total Deaths exceeded the Total Births.

YEAR.	BIRTHS.	Deaths from all Causes.	Deaths from Small-pox.	Excess of Deaths over Births.
1728-9	111	162	66	51
1736-7	135	147	66	12
1740-1	95	164	65	69
1749-50	134	149	79	15
1754-5	146	203	95	57
1757-8	125	132	37	7
1762-3	132	173	66	41
Total,	878	1,130	474	252

It may be profitable to compare the greatest Kilmarnock epidemic of modern times with the greatest to be found in the old register. In the year ending May, 1874, 141 deaths from small-pox took place in a Kilmarnock of 24,000 inhabitants, being at the rate of 5·8 per 1000 living. In 1754, 95 deaths took place in a population of 4,200, or at the rate of 22·6 per 1,000 living. The old epidemic was therefore four times more severe than the modern one. And it is to be remembered that, while the former had only a period of 4½ years in which to collect its victims, no serious epidemic had occurred for upwards of thirty years previous to 1874. One can hardly conceive what would be said now-a-days about an ordinary annual death-rate as great as that of what we have learned to look on as a terrible epidemic—one which anti-vaccinationists held to prove the futility of Jenner's discovery. And yet an annual epidemic equal to that of 1873-4 would do little more than represent the condition of matters in the last century.

In all, 622 deaths resulted from small-pox in the 36 years. The total deaths from all causes were 3,860. Of every 1,000 deaths, therefore, 161 were owing to small-pox. The meaning of these figures can best be got at by comparison. Taking as a basis the statistics of the 26 years following the introduction of compulsory vaccination into England and Wales, the results are very striking. The small-pox death-rate per 100,000 per annum, in these 26 years, was 20·8. In Kilmarnock, last century, it was 410; that is, for every one death under the vaccination laws there were nearly 20 when vaccination was unknown. Again, of every 1,000 deaths in Kilmarnock, 161 were from small-pox, while in the 26 years ending 1879, only 9·9 per 1,000 were due to it, the proportion being 16 to 1 by this method of comparison.

I wish now to call your attention to an important series of facts brought to light by the old register—namely, as to the age of the victims of these numerous epidemics. Table IV. shows that from the height of the first epidemic to that of the second one, was a period of 4 years 8 months. And of the 45 children who succumbed in 1733, 44 were less than 4 years 8 months old, the remaining one being 7 years of age. Thus only one child that died in the 1733 epidemic had been alive previous to the height of the 1728 epidemic. The disease had to secure its victims almost wholly from the population that had come into existence since its last visitation. One epidemic left almost no victims for its successors—in the same way, hardly any had been left to it by its predecessors. It called at every door, and nearly

TABLE IV.

e of rmic.	Interval since height of former Epidemic.	Total Deaths.	Deaths in Children born since height of former Epidemic.	Deaths in Children who had passed safely through one Epidemic.	Deaths in Individuals who had passed through more than one Epidemic.
-9	Unknown.	66	...	...	...
	4 yrs. 5 mons.	45	44	1	0
	3 ,, 5 ,,	66	58	7	1
	3 ,, 7 ,,	66	60	5	1
-5	4 ,, 8 ,,	74	67	6	1
-50	5 ,, 0 ,,	84	79	4	1
	4 ,, 6 ,,	95	84	11	0
-8.	3 ,, 2 ,,	45	39	6	0
	4 ,, 8 ,,	66	53	11	2
s occurring between pidemics, - -		14	8	5	1
TOTALS, - -		555	492 Or 87 per cent.	56 Or 11 per cent.	7 Or 1 per cent.

all who were not disease-proof came within its grasp. Those who recovered grew up disfigured for life; the names of the remainder are recorded in the old register book. The leading fact shown by Table IV. is that, on an average, 87 per cent. of those who died in one epidemic had been born since the previous one, that 11 per cent. who died had passed safely through one epidemic, and that only 1 per cent. had lived through more than one outbreak. In the 36 years only 3 deaths occurred in people over 20 years of age, one a lad aged 20, another a married woman aged 21, and the third, a dragoon, aged 26 years, who, from his occupation and name (Aspdal), was probably an "incomer" to the town, as the old registrar calls strangers, to distinguish them from the "indwellers" or settled inhabitants.

Table V. shows that practically these epidemics, to nearly nine-tenths of their extent, did not occur in a population of 4,200, but in a population of 475 persons. And the average number of deaths in this population was 60, or at the very high rate of 126 per 1,000 living in each epidemic year. Now the number of attacks in unvaccinated children under 5 years of age is two for every death. As many die as recover. Therefore, of every 100 children born in Kilmarnock, no less than 25 were seized with small-pox at the first epidemic after their birth. Mr. Peter Taylor, M.P., President of the Anti-Vaccination Society, has

TABLE V.

Section of Population Born since former Epidemic.

Height of Epidemic.	Born since height of former Epidemic.	Died from various Diseases, excluding Small-pox.	Remaining to form field for new Epidemic.
May, 1733,	614	90	524
Oct., 1736,	476	82	394
May, 1740,	501	89	412
Jan., 1745,	506	68	438
Jan., 1750,	634	107	527
July, 1754,	648	131	517
Sept., 1757,	445	41	404
May, 1762,	690	110	580
TOTALS,	4,514	718	3,796
AVERAGES,	564	89	475

recently issued 200,000 copies of a pamphlet, which is said, by the *Edinburgh Evening News*, to be "by far the most staggering representation of the case against vaccination that has yet come before the public." In this pamphlet he says, "that one of the characteristics of the devotees to vaccination is enormously to exaggerate the prevalence of and mortality from small-pox in pre-vaccination periods." I wonder if Mr. Taylor knows of any "devotee" who ever pictured a greater prevalence of small-pox than I have proved to exist in Kilmarnock; and as to its mortality, if, as he says, only 18 deaths took place in every hundred attacks in the last century, at all ages (and in the 622 deaths in Kilmarnock only 2 were those of adults, so that, as to small-pox, childhood practically meant "all ages"), then we must come to the conclusion that in 1754, of 517 children, 466 were attacked; in 1745, of 438 children, 372 were attacked; and in 1736, of 394 children, 322 were attacked; and so on. These figures seem to me to greatly exaggerate the prevalence of the disease; but, if Mr. Taylor is right as to the rate of attacks to the mortality, he must also accept this legitimate result of his view. Tables IV. and V. show that, as regards small-pox, there were, in fact, three Kilmarnocks. One, a Kilmarnock of 3,700 persons, had no fear of its attacks. These had already met with and battled with the disease-fiend. On many were to be seen the marks of the conflict. Some were blind, some had lost their hearing, many were permanently injured in constitution, and very many were scarred and disfigured for life; and, for every one who had conquered, another had fallen never to rise again. There was, indeed, a second Kilmarnock under the green sod of the kirkyard. The Kilmarnock which had reason to dread the epidemic's approach was a Kilmarnock the least able to meet it. It consisted of a band of little children, numbering less than five hundred in all. Every such group that came into existence had to face, within four or five years of birth, the most terrible physical enemy that it would ever meet; and, having fought the battle, some were added to the maimed and distorted who formed so large a portion of the population, and others were laid beside those who had been destroyed by former epidemics. One can barely imagine what must have been the feelings of a mother regarding these fearful visitations. Even when the town was free of the pestilence, there would be the constant foreboding of its all too certain coming; and when at last the first case occurred—when the doctor was called in, and pronounced the disease to be the dreaded pox—his words would be heard as a sentence of death to some member of almost every family containing little ones; and, as the news spread from house to house, with what a despairing clutch would each mother press her darling to her breast, and beg Almighty God to command the destroying angel to pass by her door! After the lapse of a hundred and fifty years, one can have little conception of the real meaning of a small-pox epidemic. But the old parish registrar has enabled us to apprehend something of its horror; and I venture to say that, if the anti-vaccinationists had their will, we would ere many years be again experiencing somewhat of the awful visitations which were so familiar in old Kilmarnock.

By the English life tables I find that, of every thousand children born alive, 2·3 may be expected to die of small-pox before reaching five years of age. In Kilmarnock, 116 of every thousand born were fated to die of the malady under the same age. This comparison gives the startling proportion of 1 to 35. I have stated above that the proportion at all ages is 1 to 16 or 20; and the meaning of the difference between 16 or 20, and 35, is simply this—that vaccination gives a protection much greater in childhood than in after-life; and, if re-vaccination were insisted on at adolescence, I see no reason to doubt that 35 to 1 might become the proportion all through life.

The earliest age at which the register shows small-pox to have proved fatal was 20 days, the greatest 26 years. By looking at the summations of the columns in Table II. you will see the number of deaths at each year of age. The mean age of those under 1 year was 7½ months. The mean or average age at death, of all the cases, was 2·62 years. In England, from 1848 to 1872, the mean age was 11·9 years. The difference between 2·62 and 11·9 is sufficiently striking. But in the earlier part of the 25 years 1848-72 vaccination was not compulsory. From data furnished me by Dr. Robertson, of the Register House, Edinburgh, I am enabled to state that the mean age at death, in Scotland, in the years 1873-4-5, was 13·7 years; and to Dr. Ogle of Somerset House, I am indebted for the fact that "the mean age of the 14,554 persons who died from small-pox in England and Wales, during the seven years 1872-78, has been found to be 19·98, or almost twenty years." Now, small-pox is a much more fatal disease in infancy than in manhood. In unvaccinated children under five years old, one dies in every two attacked. In youths from 15 to 20, one dies in four; so that even if infant vaccination made an attack of small-pox no milder, it would still have the great merit of deferring it till the poison-resisting power of nature is at, or at least nearer to, its maximum. And if vaccination did nothing else, it would obviously confer an enormous boon on humanity, in increasing by 17 years the life of those who do finally succumb to the ravages of small-pox. In the absence of primary vaccination death occurs at an average of 2½ years after the birth of the child. In the absence of re-vaccination death takes place at an average of about four years after puberty. It is, of course, easily possible to be led astray by averages, but granting this, these facts still point to the propriety of re-vaccination at adolescence. This is also shown by statistics of deaths in Kilmarnock since 1855. From 1855 to 1864 inclusive, vaccination was optional, and by no means universally performed, and the mean age at death was 4·38 years. From 1865, when the Compulsory Vaccination Act for Scotland came into force, to 1879, inclusive, the mean age has been 20·1 years. This last rate practically refers to the epidemic of 1873-4, as after 1865 no death took place in Kilmarnock for six years. During the epidemic there were 141 deaths. Of the 2,400 inhabitants over 3,000 were re-vaccinated. And, so far as I can learn, not one re-vaccinated person was attacked by the disease. Certainly not one died of it. This is a very remarkable fact. The 3,000 among the 24,000 were like the Israelites in Egypt, when, with their lintels and door-posts stained with blood, they were d over by the angel of death on his visit of desolation to the eholds of their oppressors.

have said that the average age of those under one year was, ilmarnock, 7½ months. Now, Dr. Robertson, of Edinburgh, , in one of the Registrar's blue books, a very interesting arison as to the deaths of children under one year old. He d that from 1855 to 1864, when vaccination was only optional, umber of deaths from small-pox in children under one year as very nearly equally divided between the two halves of the

But when vaccination became compulsory at the age of onths, this grouping altered very much—about 79 per 100 under 6 months, and only 21 between 6 and 12 months. inference was that vaccination made the difference. But rd fact was needed to complete the comparison, namely, the ortion in each of the two half years when vaccination was ly unknown. This is supplied by the Kilmarnock statistics, able VI. gives the result.

TABLE VI.

of Deaths from Small-pox between 6 and 12 Months of Age, to 100 ths from Small-pox under 6 Months, during three Selected Periods.

AGE.	1728-1763. Kilmarnock. Vaccination Unknown.	1855-1864. Scotland. Vaccination Optional.	1865-1879. Scotland. Vaccination Compulsory.
ler 6 months, -	100	100	100
m 6 to 12 months, -	491	103	26

e first ratio may be taken as the normal one of natural l-pox. It is a disease nearly five times as fatal in the second the first six months of life. But when modified in the d six months, by optional vaccination, the mortality decreases much—from 491 to 103. And when vaccination becomes ulsory, as in the third period, the 103 becomes reduced to 26. second half year is the first part of life on which the influence ccination is brought to bear on the prevalence of small-pox, he result is a very clear proof of the value of the compulsory

One question remains to be considered—How far the decrease in small-pox mortality is to be attributed to causes other than vaccination? I am quite prepared to grant that improved hygiene and treatment have exercised considerable effect in this direction. But they obviously have no bearing on the facts shown in Table VI. And that they account for anything more than a fraction of the enormous general improvement—an improvement at the rate of nearly 20 to 1—I distinctly deny. The following Table shows the decrease that has taken place in the mortality from various zymotic diseases since last century:—

TABLE VII.

Rate per 1,000 per Annum of Deaths from certain Zymotic Diseases in Kilmarnock in 1728-64, and in England and Wales in Recent Periods.

DISEASE.	Rate in Kilmarnock, 1728-64.	Rate in England.	Rate of Decrease.
Measles,	·615	(1861-71) ·4399	100 to 70
Whooping-cough,	·7671	,, ·5273	100 to 68
Fever (including Scarlatina),	3·4722	,, 1·8474	100 to 53
Small-pox,	4·1071	(1854-79) ·208	100 to 5

Deaths from small-pox, therefore, have decreased 14 times faster than from measles, 13 times faster than from hooping-cough, and 10 times faster than from fever.

In conclusion, allow me to re-state the chief facts I have endeavoured to set forth.

(1) Small-pox was epidemic in Kilmarnock every 4¼ years.

(2) Its death-rate per 1,000 per annum was nearly 20 times greater than it now is.

(3) Its death-rate under 5 years of age was 35 times greater than it now is.

(4) The mean age at death from small-pox was 2½ years in the last century, and is now nearly 20 years.

(5) The death-rate from small-pox in the second half year of life is now only a fourth of that in the first half year, while formerly, in the second half year, it was nearly 5 times as great as in the first half year.

(6) The small-pox death-rate has improved about 12 times as fast as the death-rate from measles, hooping-cough, and fever.

III.—*A Cheap Form of Voltaic Battery.* By Alfred R. Bennett, Member of the Society of Telegraph Engineers and of Electricians; Engineer to Messrs. D. & G. Graham, Glasgow.

[Read before the Society, 1st February, 1882.]

these days of dynamo- and magneto-electric machines and
cumulators, voltaic batteries may seem old-fashioned and out of
lace; but they have, nevertheless, functions of their own, such
the supply of electricity for domestic purposes, for telegraphy,
d telephony, which possess sufficient importance to render any
provement or economy effected in their construction worthy of
te.

The author trusts that this consideration will be deemed a
fficient excuse for bringing before the Philosophical Society of
lasgow the details of a new and exceedingly cheap form of
ltaic battery lately devised by him.

The object he had in view was to discover a combination cap-
le of performing, at less cost, the duties at present so well
lfilled by the Leclanché battery. Although the new form has
t yet undergone the crucial test of prolonged trial in actual
rvice, yet for some months past it has been subjected to severe
sts side by side with the Daniel and Leclanché, and has not
scovered any evidence of inferiority, either as regards power or
rability.

The idea of the combination was suggested by the well-known
ct that iron will not rust in solutions of the caustic alkalies, a
rcumstance probably due to the non-existence in such solutions
free oxygen or free carbonic acid. It was argued from this
at if a plate of iron and a plate of zinc were immersed in such a
lution, the iron, not being attackable by the alkali, would be
rongly electro-negative to the zinc. Trial proved the idea to be
rictly correct. Not only iron, but nickel and cobalt, as well as
ld and silver, and the metals of the platinum group, were found
be practically as electro-negative to zinc as carbon itself.
arbon is at first a trifle more strongly electro-negative than iron,
ut it stores up hydrogen so readily in its pores that, when the

circuit has once been closed for a few minutes, its superiority is lost. Silver is the most electro-negative of all the metals in these solutions.

The use of iron, if practicable, has obviously several advantages to recommend it. The cheapness of the metal, and its freedom from liability to fracture, as compared with carbon, are strong points in its favour; and it affords, besides, the possibility of making a perfect and permanent connection on the negative plate for the binding-screw—an end so difficult to accomplish when carbon is used. In the Leclanché, for instance, although every care is taken, by compressing the leaden boss upon the carbon and saturating the upper portion of the plate with melted paraffin wax, the solution of ammonium chloride—which in that battery is the exciting chemical—creeps up and attacks the lead, with the result that, after some months, plumbic chloride is formed at the junction, and gradually impairs the integrity of the connection. It rarely interrupts communication entirely, but, by interposing resistance in the circuit, detracts from the efficiency of the battery. With an iron plate, a soldered joint can be made, and permanency secured.

It was discovered, however, that a simple iron plate polarized very rapidly, the hydrogen set free by the action of the battery clinging to it, and greatly increasing the resistance. By surrounding the plate with a packing of small fragments of iron, such as clean turnings or borings—in the same manner as the carbon plate in the original form of Leclanché is surrounded by fragments of carbon and manganese dioxide—this deleterious action is considerably modified, and the cell acquires to a great extent the power of keeping up its electro-motive force when working continuously through a low external resistance. The number of points presented by the turnings or borings is probably the cause of this, as it is well known that hydrogen escapes with much greater freedom from a rough than from a smooth surface. The packing of iron fragments is, in fact, the platinised silver plate of Smee in another form. The greatest efficiency is obtained when the iron fragments are thoroughly damped by the solution, but not immersed in it, the obstacles to the escape of the hydrogen being then at their minimum. The cell works very well, however, when the iron is covered. Although not quite constant when working through an external resistance of 20 ohms, the battery recovers its original electro-motive force, when allowed to rest, with a rapidity sufficient to allow of its employment on the busiest telegraphic circuits, and for most other practical purposes.

The electro-motive force of the iron battery varies somewhat with the nature of the iron, and the degree to which the packing is saturated or covered by the solution. The Daniel being 1, and the Leclanché, at its best, 1·30; the iron varies from 1·15 to 1·33. The last was an exceptionally good cell, and the average may be taken at 1·23, or ·07 less than the best Leclanché.

But, after working for some days continuously through a low external resistance, the iron keeps up its electro-motive force much better than the Leclanché. This was proved lately, at the suggestion of Mr. David Graham, who thought it likely to demonstrate the comparative merits of the batteries in actual service, by setting a good specimen of each cell to ring an electro-magnetic trembling bell night and day until they failed, the bells being of precisely similar construction, and each of a resistance of 5 ohms. They were started at 11.10 a.m. on December 23rd last. After a few days, the Leclanché became very weak, and, although it did not actually stop until January 12th, it latterly simply vibrated the hammer of the bell without striking the gong. The iron cell rang the bell powerfully until January 15th, and did not stop until January 23rd, exactly one month, or 744 hours from the date of starting.

The chemical reaction of the iron battery is probably as follows. There being present when a solution of potassium hydroxide is used:

$$Zn_2 + KHO + H_2O + Fe,$$

the closing of the circuit produces first.

$$2\,Zn\,O + K + Fe + H_3.$$

That is to say, at the positive plate the oxygen of the potassium hydroxide and of the water is given off, and combines with two atoms of zinc to form zinc oxide. At the negative plate, the potassium and the hydrogen of the potassium hydroxide and the hydrogen of the water are set free. The metallic potassium instantly decomposes an additional molecule of water in the *negative* portion of the cell, with the oxygen of which, and one of the free atoms of hydrogen, it combines to re-form potassium hydroxide, leaving the four atoms of hydrogen due to the decomposition of water free. This makes the final stage

$$2\,Zn\,O + KHO + Fe + H_4.$$

It is to the polarising action of this free hydrogen that the inconstancy of the electro-motive force of the combination is due. It however, as already stated, ascends between the iron fragments and rapidly escapes to the air. The caustic solution is, consequently, used up in the positive half of the battery, and re-formed in the negative.

The author has attempted in many different ways to get rid of the obnoxious hydrogen, but without permanent success. Mixing platinum black with the iron packing answers to some extent for a time, as the platinum absorbs the gas, and leaves the iron free. Another plan is to place a chemical having a great affinity for oxygen, such as pyrogallic acid, phosphorus, cobalt nitrate, potassium or sodium permanganates, at the negative plate. But the chemicals which absorb oxygen with sufficient avidity have little permanency, and soon cease to act. The presence of a permanganate raises the electro-motive force of the battery, in addition to improving its constancy, but the effect is transient. A cell was placed in a jar of compressed oxygen, in hopes that this gas would find its way through the iron packing and combine with the free hydrogen to form water. But the hydrogen would have nothing to say to the oxygen until it was clear of the battery. It then combined, and the cell, being kept at work, was in a couple of weeks drowned in water of its own creating. These are, however, [illegible] complications which, besides being superfluous, are in[illegible] the score of expense in a cheap battery, which the [illegible] is specially designed to be. Its cheapnes [illegible] which it can be made up, are, indeed, its mo [illegible] There is here an old tinned iron can, whic [illegible] distinctly states, was originally packed wit [illegible] At that time there was little probability [illegible] making its appearance before such [illegible] The beef having been consume [illegible] Her Majesty's lieges, now unknown, th [illegible] and was acquired, without muc [illegible] the firm of Messrs. D. & G. [illegible] farthing sterling. There is also here [illegible] from the floor of an engineer's [illegible] the time and trouble consumed in [illegible] There is [illegible] of common zinc, cut from an old [illegible] and a bottle containing a solution of [illegible] hydroxide.

The porous cell being placed in the tinned iron can, the borings are packed tightly around it, the solution is poured in, and the zinc strip immersed in it. The ends of an electric bell circuit being attached to the can and the zinc strip, the fact that a powerful current has already been set up is made sufficiently obvious. [*Experiment shown.*] After a few minutes it will become still more powerful; and if left to itself the cell would ring the bell night and day for at least three weeks without any noticeable loss of energy.

The differences of electro-motive force or capacity for outside work of the various types of batteries may be roughly shown in the following manner:—Here is a Daniel cell joined through a box of resistance coils and an electro-magnetic trembling bell of 5 ohms resistance. Through no resistance but its own and that of the bell it makes a considerable noise, but by gradually introducing resistance this is diminished until, when 22 ohms have been plugged out, the hammer is vibrated without striking the gong. This effect is produced through 5 ohms, its own internal resistance—5 ohms the resistance of the bell, and 22 ohms inserted resistance, a total of 32 ohms. Taking an iron cell instead of the Daniel, to bring about a similar state of affairs, 35 ohms have to be plugged out, which, adding 5 for the bell and one for the internal resistance of the battery, makes a total of 41. Substituting a Leclanché, one additional ohm is needed, or a total of 42. With an iron cell superexcited with permanganate of potash, no less than 50 ohms have to be plugged out, or a total of 56, before the hammer ceases to strike the gong. The electromotive forces of the four cells are then in the proportions

1 1·28 1·31 1·75.

In volts the figures become

1·079 1·381 1·413 1·888.

This method corresponds to the reproduction of a constant deflection on a galvanometer. It is not to be commended for strict accuracy, but by its means it is possible to demonstrate to an audience facts which otherwise could only be referred to verbally. The results, too, are substantially correct, agreeing well with observations made with far more delicate instruments.

The tendency of the caustic alkalies to absorb carbonic acid from the air renders it desirable, although not absolutely necessary, to keep the porous cell which contains the solution tightly covered.

On the other hand the iron portion of the battery should be exposed as freely to the air as possible, to facilitate the escape of the hydrogen. These contrary conditions are rather vexatious, but by no means impossible of attainment. The most practicable mode of solving the difficulty appears to be the placing of the positive portion of the combination in an earthenware cell about 7 inches in height, but porous only for 4 inches from its bottom, which porous cell is fitted with an air-tight stopper, through which the zinc rod is brought, and terminated by a binding screw. The earthenware cell is placed in an iron can, 5 inches in height, and of a like diameter, and packed in firmly with turnings or borings. The earthenware cell having been filled with solution almost to overflowing, the air-tight stopper is fitted in, and the battery is ready for use. The advantages of this arrangement are the exclusion of carbonic acid from the caustic solution, while the iron is left exposed to the air, the prevention of evaporation, and the preservation of the packing from too profuse a wetting. There being no air pressure on the surface of the solution in the earthenware cell, it can only percolate with extreme slowness, being opposed by the pressure of the air, acting through the iron borings and the pores of the cell.

The presence of carbonic acid in ordinary water renders it desirable to make the solution with distilled or newly-boiled water. If this is done, and the cell instantly closed with an air-tight stopper, the conditions necessary to secure the best results have been complied with. Instead of distilled or boiled, common water may be used, if a portion of newly slaked lime is added to the cell before closing. For ordinary purposes, however, these precautions may be dispensed with.

Now, as to cost. The tinned iron can may be used without detriment. The tin, being strongly electro-positive to iron, sets up a local action with the borings as soon as the solution reaches it, and, being small in quantity, is soon converted into tin oxide without injury to the battery.

The soldered joints of American preserve cans are but very little affected by the solution, and can be depended upon not to leak if tight in the first instance. Solders in which tin or zinc are present ought to be attacked, but copper and lead are but little acted upon. The joints of such cans are probably so carefully made in the first instance as to be mostly water-tight without the aid of solder. These cans may, therefore, be regarded as perfectly efficient, although cheap. The cost of one, including the borings, which are by no means scarce in Glasgow, may safely be put down at one farthing. The borings never need renewal, as they do not rust, and are not changed in any way by the action of the battery. The zinc may be of the commonest kind, as no local action of importance has been observed, unless the caustic used is very impure. Amalgamation is, therefore, useless. Strips of common roofing zinc, rolled into cylinders, answer perfectly well. The porous cell is the most expensive item, but this can be dispensed with by the use of diaphragms of canvas or other fabric of vegetable origin. It must be remembered that the caustic alkalies destroy all animal tissues, so leather, bladders, &c., are not admissible. The author has tried cells of thin wood, such as willow boxes, with success; but the earthenware is more permanent, and, in spite of its prime cost, probably the most satisfactory in the end. Such as the one before you can be procured wholesale at 2d. each. Caustic soda, in a state of reasonable purity, is made in the neighbourhood of Glasgow, and can be obtained wholesale at a little over a 1d. per lb. As 4 oz. will last a long time, this item is not excessive. To sum up the cost of one cell in its simplest form, we have—

Can and borings, ...	¼d.
Porous cell, ...	2d.
Zinc, say	1d.
Soda, 4 oz., ...	½d.
Soldered wires for connections, ...	1d.
Labour, ...	1¼d.
Total, ...	6d.

which is quite a liberal allowance.

The battery, consequently, is probably the cheapest ever devised, in proportion to its power and durability, when regarded in the light of prime cost, but it becomes even cheaper when it is considered that the chief product of its action is zinc oxide, known in the paint trade as zinc white, which is extensively used as a pigment, and as a substitute for white lead. It can easily be recovered in an approximately pure state from the used-up battery. From the cell which rang the bell for a month, 1,458 grains, or 3·04 oz. troy, were recovered, the zinc consumed being 1170·7 grains, or 2·44 oz. troy. Some of it is on the table before you. Its price in the market ranges from 6d. to 1s. 6d. per lb., according to rust. [illegible] is by no means a bad sample, containing only a slight trace of iron. It [illegible] [illegible] that if the zinc consumed it has been said that voltaic batteries can never compete with dynamo-machines, because the zinc itself takes coal to reduce it from its ores to the metallic form, which coal would have produced the energy direct if burned in the furnace of a steam-engine driving a dynamo. But if the residues of the consumption of zinc in a voltaic battery can be made to defray the cost of the zinc, that oft-quoted argument somewhat loses its force.

However that may be, it is pretty evident that the man who can buy, borrow, or —— otherwise become possessed of a few old preserve cans, a corresponding number of porous cells, a quantity of iron borings, with a few lbs. of caustic soda, and who has an old wife to set up—an old chimney-can of the pattern known as the old wife is, of course, meant—can conjure up and render subservient to his wants or his amusement in many ways that mysterious but beneficent force which we know as electricity. He may, perhaps, even light his library on a small scale, or drive his wife's sewing machine; and, after all, when the battery ceases to work, he can take it to pieces and paint his house, or a part of it, with the products.

The battery, however, need not be made cheaply. It lends itself with equal facility to the taste of the sybarite as to the means of the working-man. As before stated, nickel, cobalt, silver, gold, platinum, are all strongly electro-negative to zinc in caustic alkalies, and might all be used to good purpose. A golden goblet packed with half-sovereigns, instead of a tinned can packed with iron borings, would ring an electric bell, or work a telephone admirably, as would also a silver chalice packed with sixpences; so it is obvious that refinement is possible in voltaic batteries as in everything else. It may be noted that copper also answers well instead of iron for a time, but a soluble salt of copper is gradually formed, which is precipitated upon, and stops the action of the zinc. On the table are various forms of the battery. In some, the negative plate, consisting of an old file, an old knife, or a spiral of iron wire, is packed with the borings in a porous cell, the positive portion of the battery in such cases being in a glass or earthenware jar.

IX.—*Opening Address to the Chemical Section.* By James Mactear, Esq., F.C.S., F.I.C.; Medallist, Society of Arts; Graham Medallist; President of Chemical Section of Philosophical Society.

[Read before the Chemical Section, 7th November, 1881.]

I have again, to-night, the pleasure of greeting you on the commencement of a new Session, and while congratulating you on the very successful one just passed, to express my hope that the one to come will be even still more successful.

We have—I am happy to say—had papers promised, which will give us a good start, and the Council of the Section look for cordial support and co-operation amongst the members, and specially the associates of the Section, to enable them to arrange for the evenings which remain to be filled up.

There has all along, in the history of this Section, been an apparent reluctance on the part of the associates to come forward with papers, or subjects for discussion, which is much to be regretted. If you look over the names of those who have read papers before us, you will be astonished to find how few are those upon whom it has fallen to bear the "heat and burden of the day," and you will feel, as I do, the urgent need of the young blood coming to the front, and taking a greater share of the work which has to be done. Let me then urge (as this is the last occasion upon which I shall have the honour of addressing you as your President), as strongly as it is possible for me to do, that any member or associate who has some little subject about which he knows more than we do, will bring it before us, either in the form of a paper, a mere short note of the facts, or as the subject of a discussion.

It is, I can assure you, no light matter for your Council to undertake to supply, session after session, the pabulum for which you crave, and it is high time that some of the younger men "take hold," and lend their efficient aid.

In another way than in supplying papers they can help us by turning out in greater force to the meetings. It is very disheartening to find these meetings so poorly attended as they too often are. What is to blame for it? Surely the chemical industries of the second city in the kingdom ought to be able to produce a better attendance. If it is the quality of the papers, then let that be your task to amend it. If the subjects are not those which interest you, then even suggestions to the Council as to what subjects would be most interesting to the Section and likely to bring out a good attendance; or an interesting discussion might enable them to get some one to take up such subject and come forward with a paper. In such a city as ours, where there are to be found examples of almost all classes of chemical industry, surely there can be no want of subjects, nor, let us hope, of willing members to bring them before us; and I trust that the appeal I now make to you, not for myself, but for my successor in this chair, will not be in vain, and that the sessions to come will be yet more successful than any of those upon which we can now look back.

It is usual in a presidential address to make it very much a résumé of the advance made in the previous year. This is a very sound system to go upon, but unfortunately it, in my case, would require an amount of leisure time for scientific reading that I cannot possibly find; and in chemical science the field is so large, and the advances made are so rapid and varied, that it is scarcely possible for one man to study them all—certainly not for one engaged in technical work, where, unless he adheres pretty closely to a special branch of study, he is apt to lag behind the rapid advance which takes place in these our days.

I have thought it would be interesting, and not without instruction, if I were to put before you some notes on the *History of the Technology of Sulphuric Acid*, and attempt to trace the various stages and changes through which the manufacture has passed ere reaching its present system.

When vitriol was first made, or by whom, will never be accurately known, but it would appear that it was known to Abou Beke Al-rhases, who died in 940 A.D. As I have shown in the address which I had the pleasure of delivering to you in December, 1879, "On the Antiquity of the Chemical Art," the Arabians were indebted for much of their knowledge to the inhabitants of India; and Dr. Ainslie has shown, from the evidence of old Indian medical works, that there is strong proof that vitriol was made in India long prior to Al-rhases, by burning sulphur and nitre in clay vessels.

The most probable origin of the manufacture of vitriol by artificial means, I believe to be due to the fact that in the use of sulphur for fumigation, and in bleaching cloth by its fumes while burning, there would soon be noticed the fact that an acid liquid was formed, and this would soon lead up to a rude attempt to manufacture this acid by the process called later on the process of the bell. Be this as it may, however, it is in the writings of the Arabian philosophers that we first find mention of the method of preparing oil of vitriol, A.D. 778—Geber, for example, having produced it by distilling a mixture of alum and sulphate of iron.

1200. The acid is mentioned by Albertus Magnus, under the designation of Sulphur of the Philosophers and Spirit of Roman Vitriol.

1490. Basil Valentine is often credited with being the first to mention sulphuric acid, but this is clearly an error, it having been known before his time. He refers to it as the blood of the green lion—*i.e.*, green vitriol or sulphate of iron.

1541. George Agricola, in his famous book De Re Metallica, mentions its preparation from pyrites by first forming sulphate of iron, by oxidation, solution, and crystallization, and then distilling.

1570. But Gerard Dornacus was the first who gave what may be called a correct description of the acid, in a work published in 1570, and which was republished in 1581.

1595 (*circa*). To Andreas Libavius, of Halle, we owe a great deal, as being one of the first who attempted to clear the science of chemistry from the morbid growths of the alchemical dreamers. As regards our special subject, he was aware of the action of nitric acid on sulphur as yielding sulphuric acid, and very probably from reasoning upon the fact (1616), actually produced sulphuric acid from the combustion of a mixture of nitre and sulphur. He also determined with great care the nature of vitriol, and showed it was the same whether produced from sulphate of iron or from sulphur.

To him we owe the first imitation, therefore, of the process which has now such an extended application.

1647. Following him we have Angelus Sala, also an enlightened and careful worker. He was physician to the Duke of Mecklenburg-Schwerin. He recommended sulphuric acid as an excellent medicine, and showed that it could be equally well prepared from blue or green vitriol or from sulphur.

1647-50. Glauber, in his work, published first in 1648-50, describes very clearly the preparation of the acid and special apparatus for its production. At this time it must have been well known, as he says (Eng. Ed., 1689), "the corrosive oil of "vitriol is to be found in almost every apothecaries' shop." He also says, in his Treatise on the Three Principles of Metals—viz., the sulphur, mercury, and salt of philosophers—in regard to sulphur, that it was usual to prepare from it, as medicaments, yellow flowers, a white majistery, a red balsam, and an *acid oyl per campan.*

Further on he quotes Basilius as treating of the fixation of 🜍 (sulphur) by help of salt nitre, and saying (salt nitre, being supposed to be speaking of himself)—"Sulphur is indeed my most "mortal enemy, and he is also my best friend; for when we both "are joined in wedlock and our marriage celebrated in hell, so as "we both sweat well together, then we shall so put off all impurities from us, as in our dead bodies may be found the greatest "treasures, and of us be progenited wealthy children," &c.

He also in mystic language describes how to oxidise sulphur with nitric acid, and then to distil, there remaining an "antidote or treacle," evidently oil of vitriol.

In the 3rd part he says—"I thought it necessary here to publish "that oyl of vitriol may be prepared divers ways, so as one or "another may prepare it, this way or that way as he pleaseth." And in his corollary he says:—

"Therefore I forbear to write now at this time. Let him "who cannot content himself with those here written, search the "monuments of philosophers writing that there is such an art, by "the benefit of which, with one only pound of coals, a whole "pound of oyl of vitriol may be distilled. Yet such an artifice "must not so soon be spread among the people. To whomsoever "God reveals the same he may prepare it according to his own "desires; if it be otherwise, let him comfort himself with this "meditation of patience, viz.:—that he was not worthy of so "great gifts."

Glauber was, like most of the chemists of his time, not a little egotistical, as the following verse from his book of dialogues will show.

"It was," he says, "presented to him by a learned man"—

"Thy sirname, John Glauber! given was, as unto faith relating,
"Yet by good right it should have squared unto thy operating;
"Faith's objects are invisible, but yet such things do you,
"As would at first be scarce believed, produce by art to view."

He further on speaks of the common way of making the corrosive oyl of vitriol, as requiring a fire to be kept up for 40 or 50 hours, which is a very tedious work; but the adepts can force over a pound of oyl of vitriol in an hour's time, with very few coals.

"I have recommended this compendious method of making oyl of vitriol and sulphur to some men, but they adhered so close to their old lingering way that they were regardless of a better, notwithstanding that the oyl of vitriol and the acidum of sulphur are the basis of all the common hermetical medicines, for all other mineral spirits are by them easily to be obtained."

It is easily seen, therefore, that he was perfectly alive to the fact that sulphuric acid could be produced either by the distillation of the sulphates or by the combustion of sulphur alone, or in admixture with nitre, as well as by the oxidation of sulphur by nitric acid.

Referring to its production from sulphur, he says (P. 54, Part I., pt. 2, Phil. Furnaces):—

"1600 A.D. To reduce sulphur into a soure spirit or oyl hath been sought hitherto by many, but found by few. Most of them made it in glass bells, but got very little that way, for the glasses, being quickly hot, could not hold the oyl, so that it went away in a smoak.

"Some thought to get it by distilling, others by dissolving, but none of all these would do the feat, which is the reason why now-a-days it is to be found almost nowhere right; and in the drugsters' and apothecaries' shops they usually sell oyl of vitriol instead of it, which by far is not to be compared in virtue to the oyl of sulphur, for this is not only of a far pleasanter soure taste, but in efficacy also much exceeds the other. * * * * *

"I thought good to set down the preparation, though it be not done in this our distilling furnace, but in another way, by kindling and burning it, as followeth:—

"Make a little furnace with a grate, upon which a strong crucible must be fastened, resting on two iron bars, and it is to be ordered so that the smoak be conveyed (not above by the crucible, but) through a pipe at the side of the furnace; the crucible must be filled with sulphur even to the top, and by a coal fire, without flame, be brought to burn and kept burning.

"Over the burning sulphur a vessel is to be applied of good strong earth, like unto a flat dish with an high brim, wherein is always cold water to be kept, and whereunto the burning sulphur doth flame, which thus burning its fatness consumeth, and the acid salt is freed and sublimed to the cold vessel, where it is dissolved by the air, and in the form of a sharp oyl runs from the hollow vessel into the receiver, which must be taken off sometime and more sulphur supplied, instead of that which hath been consumed, to the end that the sulphur may still burn in the crucible, and beat with the flame to the cold head; and within few days you will get a great quantity of oyl, which else by the (campand) glass bell in many weeks could not have been done."

I have here a rough drawing of a furnace designed by Glauber, for the production of oyl of sulphur. It is not very fully described, but is to be made of good stoneware, hard burnt, and "in its diameter at least two feet broad, or rather if it may be, three." [See Plates III. and IV.]

In the drawing the various parts are marked by letters:—

A is the standing part of the furnace.

B the lower hemisphere or half globe, which is to contain the sulphur, or what you intend to make into oils or spirits.

C the upper hemisphere, with its pipe to draw the oils or spirits by.

D the body to hold the water.

E the cavity or top of the body to put in the water.

This form he improved upon in his so-called second furnace, of which I have here a drawing;—

A represents the Furnace, with an iron or earthen distilling vessel fastened into it, whereunto a receiver is attached.

B the distiller, with his left hand taking off the cover, and with his right hand casting in the prepared matter.

C the external form of the distilling vessel.

D the external form of the distilling vessel.

E another form of distilling vessel which is not fastened into a furnace, but standeth only upon ovals.

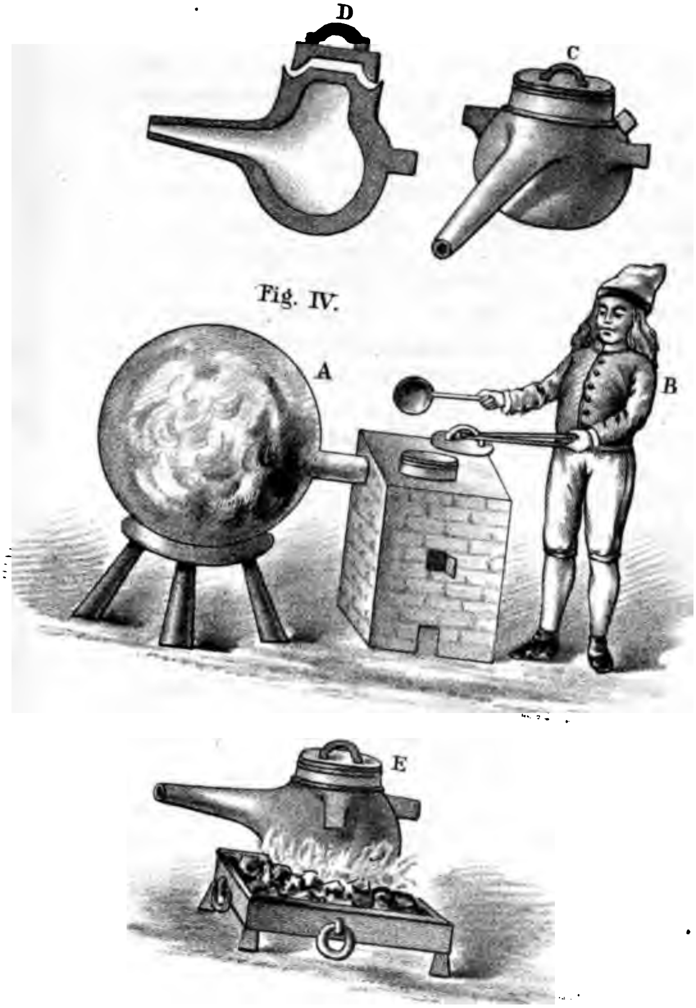
This form of furnace he speaks of as specially suitable for the distillation of oyl of vitriol from sulphate of iron.

The furnace being heated until very hot, the lute or groove in which the lid sits is to be filled with melted lead, and the operation is conducted by raising the lid and casting in the material to be treated, and at once closing the lid again. The operation is to be repeated as often as may be needed, the residues being from time to time extracted by a spatula.

1670 A.D. About the same period we have the works of

Proceedings of Philosophical Society of Glasgow, 188

PLATE III

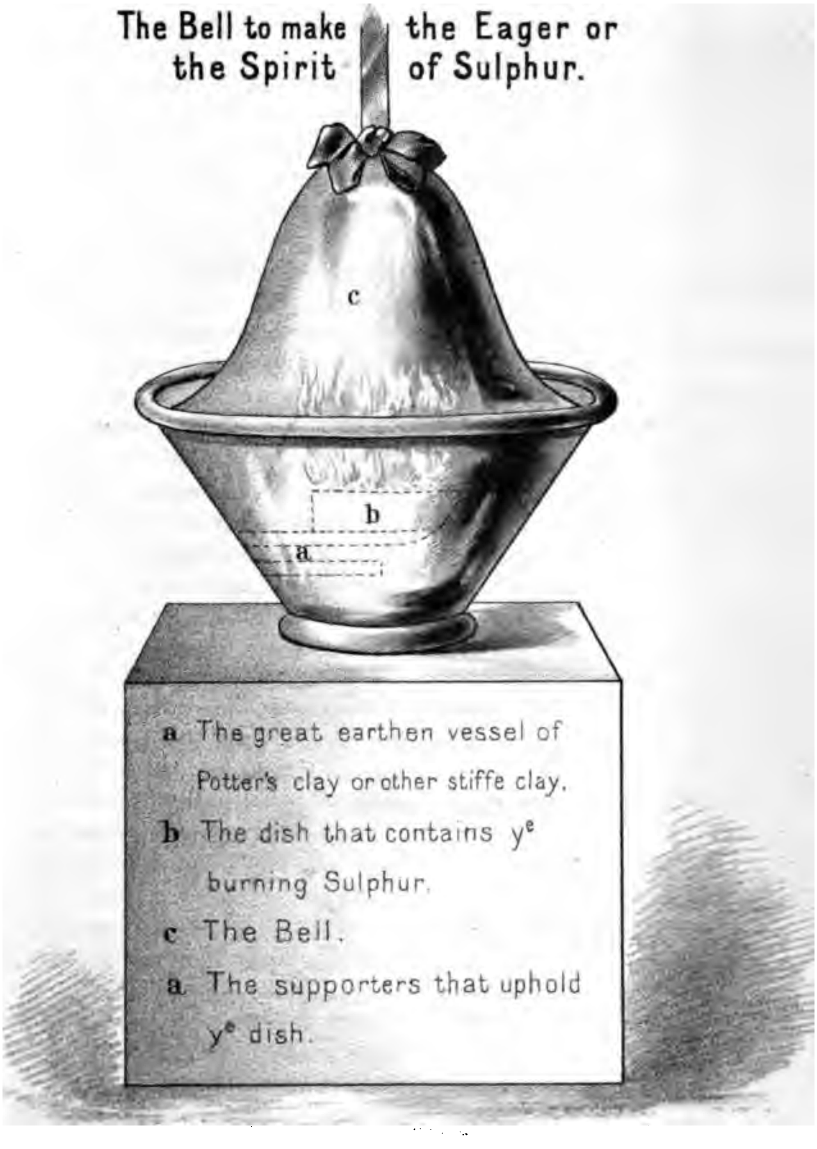


Glaubers "Second Furnace."

Proceedings of Philosophical Society of Glasgow, 1881-8

PLATE IV.

NICHOLAS LE FEBURE
1670



The Bell to make the Eager or the Spirit of Sulphur.

a The great earthen vessel of Potter's clay or other stiffe clay.

b The dish that contains y^e^ burning Sulphur.

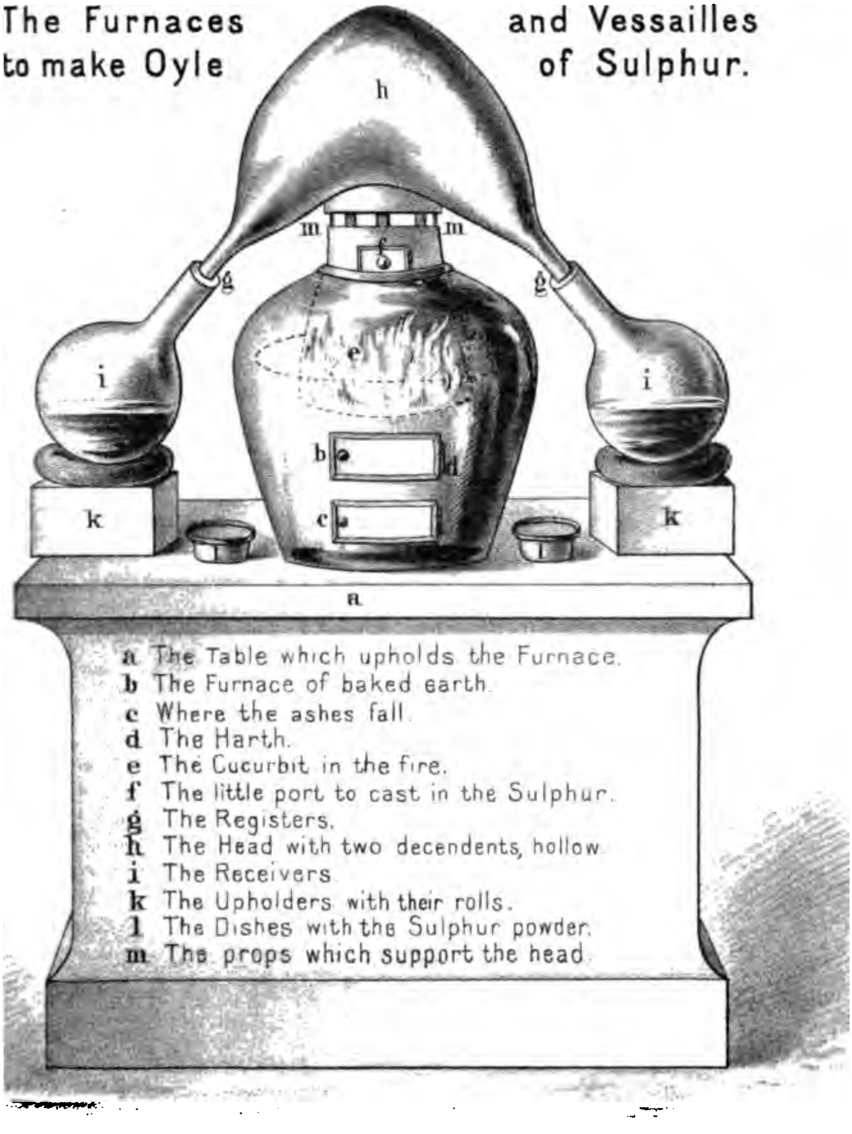
c The Bell.

a The supporters that uphold y^e^ dish.

Proceedings of Philosophical Society of Glasgow: 1881-82

PLATE V.

HOLAS LE FEBURE
1670



The Furnaces and Vessailles to make Oyle of Sulphur.

a The Table which upholds the Furnace.
b The Furnace of baked earth.
c Where the ashes fall.
d The Harth.
e The Cucurbit in the fire.
f The little port to cast in the Sulphur.
g The Registers.
h The Head with two decendents, hollow.
i The Receivers.
k The Upholders with their rolls.
l The Dishes with the Sulphur powder.
m The props which support the head.

Nicholus or Nicasius Lefibure, Royal Professor in Chymistry to His Majesty of England, and a Fellow of the Royal Society. In the English edition of his works, published in 1670, the method of producing sulphuric acid at this time is very clearly described, first by the usual distillation of sulphate of iron (or vitriol), and more especially of the sulphuric acid from sulphur, or the spirit of brimstone, as he calls it. He says (p. 300, Part II.):—

"*The distillation of sulphur.* — The sons of art have sought long how to find a way of distilling from sulphur of brimstone a good acid spirit, which they improperly call the oyl of sulphur, and to draw a quantity from it, which hath caused a hundred manners of contrivances and processes. They have also endeavoured to turn brimstone into an unctuous oil, which might be fit both for inward and outward diseases, wherein everybody hath brought his mite of experience and industry to attain that end; but, as we have found that brimstone hath been vitriol before it could attain the character of sulphur, our wonder hath been the greater that they should have laboured so much to get out that acid spirit, since they do confess themselves that the spirit of vitriol is like in virtue and operation to that of brimstone, and it will be easier to draw lb. x. from one than lb. ½ from the other.

"We must confess, notwithstanding, that there shall be something found more quick and subtil in the acid of brimstone than in that of vitriol, because the substance from which it is extracted hath been more exalted, more concocted, and ripened than vitriol, which is much inferior in these respects, and consequently more undigested.

"Wherefore we will declare two ways which have ever been very successful unto us, to draw the acid of sulphur or brimstone:— We have caused a draught to be made of the figure of the vessels for both these operations, because the mind of the artist is more forcibly toucht with the representation of them, and he may, therefore, better apprehend how to dispose of things, for objects move more powerfully the apprehensive faculty than words can do; wherefore we refer to the ensuing scheme they that shall be inclined to put in practice the following operation:—

"Take a great gray earthen pan, in the midst whereof place an iron trufoot, capable of upholding an earthen dish, glazed without and within; fill up this dish with brimstone beaten to coarse powder, and melt it by a slow heat, then set it on fire with a brimstone match, or an iron made red-hot in the fire; after which, hang up a glass bell, such as those that are used to cover melons; let it be moistened with aqua vitæ above the earthen dish, so as the flame may come in the bell, but not reach to the top or touch it; take also care that there be not more distance between the circumference of the pan and that of the bell than the breadth of an inch, or one inch and a-half, because this space is sufficient to entertain the flame of the brimstone, and hinder the extinction thereof, which, if it should happen, great care must be had to kindle it again, that no interruption may happen in the work: and when all the brimstone shall be spent, have another dish to substitute in the place of the other.

"So shall you have the true spirit of sulphur per capanum very heavy acid, and of a brown red colour, if the time hath not been too moist and the brimstone not too much impregnated with the vitriolic salt.

"And if the distilled liquor proves to be only clear and yellow, let it be rectified and the superfluous phlegm thereof drawn away.

"The artist may place as many earthen pans and bells under a chimney as it can hold to advance the more his work, for he may as easily use four or five as one. Above all things choose that of the two equinoxes—vernal and autumnal—to work this spirit, that season being moist for the most part, and rainy, which is a thing necessary in this operation, otherwise you shall draw very little spirit from lb. 1 of brimstone; because, if the air be too dry by intervention of cold or heat, it is not capable of coagulating the acid and vitriolick spirit of the brimstone, which, contrariwise, is totally dissipated with the fat and inflammable substance of the brimstone. We will speak of the virtue and faculties of this spirit after we have taught the second method of preparing it.

"*The second manner of making the spirit of sulphur and brimstone.*—Have a small furnace of baked earth capable of receiving a strong earthen cucurbit which may well endure the fire, having a square hole made in the body or belly of it, whereto a piece to close it up must be exactly fitted; let the cucurbit also have four small eminences, distant the one from the other to keep up the border of the limbeck head which is to be applied upon, that there may be room and air to let go and evacuate part of the smoke ascending from the brimstone when it takes flame, otherwise you should have nothing but acid flowers and a whitish liquor. This done, heat softly the cucurbit at first, then increase the fire until it become red, and having at hand very good mstone, well chosen and dry, beaten to gross powder, throw in ut ℥ ij. thereof at once into the cucurbit through the square e, and immediately shut it close again; thus continuing until ascending vapours begin to condensate themselves and thicken the still-head, and drop down into the recipients which must be lied to both noses of the still.

'You must also make choice of a moist and rainy weather to k this spirit, if you will have it in quantity; the time being sonable, the brimstone good, the artist watchful in keeping up fire, and throwing in brimstone as soon as the flame doth cease, may hope oz. 1½ from each lb. of brimstone. The proportion he furnace and necessary vessels for the work may be better n by the artist in the figure than we could be able to describe."

.683. In a little book, entitled

hymical Secrets and Rare Experiments in Physick and Philosopy, with Figures, Collected and Experimented by the Honourable and Learned Sir Kenelm Digby, Chancellor to the late Queen Mother of England.

ublished since his death by George Hartman, Chymist and Steward to the aforesaid Sir Kenelm.

rinted for Will Couper, at the Pelican, in Little Britain. 1683."

he second part of the volume is, curiously enough, dated 1862. here is a description of an improved arrangement of the bell cess, sent by the Abbot Boncund, of Paris, to Sir Kenelm by, evidently some years previously. It is headed

'*A process how to make a most excellent oyl of sulphur in ndance.*—Take an earthen pan of stoneware, in the midst reof lay a piece of brick, upon which set an earthen porringer of sulphur grossly beaten, then put fair water into your pan, not so much as to touch the said porringer, then kindle the phur and cover it with a bell, so that the bell touch the water, that the fumes may not come out, but may condense and run n into the water, which afterwards must be separated in B. h a moderate heat. To set the sulphur on fire, you may put it a square or round piece of iron, made red hot in the fire.

'*Note by Hartman.*—In my opinion if the bell touch the water, that it hath no hole at the top, so that the sulphur have no it will not burn. I judge the best way to be thus:—Let the ringer stand in the water, but not so deep as the water bear it and make it float; if it stand half-way in the water it will do, the weight of the sulphur will keep it down, and the heat of the porringer will heat the water, and the vapours and steams thereof will mix with the fumes of the sulphur, and make them condense the better, and so distil down together into the water.

"The bell should be such an one as is now in use, with a long neck, and a hole at the top, which should not touch the water nor the pan, but should be suspended in such a manner that there be some distance between the brim of the bell and the sides of the pan."

We have here the first attempt, so far as I can find, to use steam, instead of trusting to the moist weather usually recommended for the process, and also the idea of continuous action, by having a current of air passing through the apparatus.

About this time (in 1666, according to Wurtz), Le Fèvre and Lémery proposed the use of an admixture of nitre with the sulphur when burnt under the bell. It is usual to give Lémery the credit of this as a discovery, but I think it—he gives a process for the use of nitre and sulphur in his Churtz, 1698—will be quite evident from the extracts I have given from Glauber, that its action was known, though not clearly, and that it was employed long before Lémery's time in the process of making sulphuric acid from sulphur.

It is curious how often one comes across things of this kind, where some one gets all the credit for a discovery which has been in reality known for a long time previously. For instance, the alkali process is usually supposed to have been originated by Leblanc Dize, but in Foueroy's Chemistry, published in 1789, he says :—

"One feels to-day the need of a more important use than all "these (of common salt), the extraction of the soda, which becomes "every day more and more rare, and which is necessary in all the "arts. Many persons possess this secret in England, and with"draw on a large scale the soda from the salt of the sea."

1749. The first manufactory for the fabrication of vitriol was established by a Dr. Joshua Ward, who was granted a patent, in conjunction with a John White, in 1749, June 23rd, No. 644.

The wording of the specification is quaint, and worth giving here :—

"A certain acid spirit of sulphur, with sulphur and saltpetre, which in all things answers, and in some excels oyl or spirit of vitriol. The acid spirit of sulphur is made by powdering and mixing a proportionable quantity of roughstone or flower of brimstone and saltpetre, putting the mixture into a glass vessel and setting fire to it, which, by burning, afterwards condenses into an acid spirit of sulphur."

The quantity of sulphur and saltpetre cannot be ascertained, as they differ "not only with the quality of the sulphur and the saltpetre, but also according to the various seasons of the year and different weather, when the air has at times so extraordinary effect that without proper alterations the matter yields not above half the quantity of spirit as at other times, for which changes it is impossible to give any general rules, nor is it known but by observation and experience."

It was not till 1766 that a lead chamber was erected in France by Holeker, at Rouen, but in 1774 La Fallie introduced steam into the chamber (no doubt following in this the advice of some of the earlier chemists, who, as we have seen in the case of Sir Kenelm Digby's man Hartman, advised to have the vapours off the water rising in the bell).

Clement Desormes pointed out in 1793 that the chambers could be worked by a constant current of gas, but this idea does not seem to have been worked out till about 1810 in actual practice in France, and even later in England. So far as Scotland is concerned, the manufacture spread very rapidly, and in 1797 there were in Glasgow about at least six or eight different factories.

In this year the question of the strength of the commercial vitriol seems to have received a good deal of attention, and a set of hydrometers invented or arranged by a Mr. Foy, a chemist, at that time engaged in bleaching operations. The following is a note of the cost of manufacturing 950 bottles of vitriol (of 150 lbs. each):—

Mr. M——'s Business, 1798.

25 tons Sulphur—say at £40, ...				£1,000	0	0
7 „ Nitre „ £100, ...				700	0	0
Coals, ...				105	0	0
Wages and Houses for Men, ...				250	0	0
Tear and wear of Utensils, ...				30	0	0
Rent and Buildings, ...				70	0	0
Cartages, ...				40	0	0
				£2,195	0	0
142,500 lbs. o.v., at 6½d.,	£3,859	17	6			
Less disct. at 10 °/o, ...	385	19	9			
				3,473	17	9
Profit, ...				£1,278	17	9

This gives nearly 64 tons of acid, costing, say £32 per ton, and selling for, say £54 nett cash.

Description of method of working then in use by Messrs. Bealy, Radcliffe, near Manchester:—

May, 1799. "There were six chambers, 12 ft. by 10 ft. by 10 ft., roofed like a cottage. They were placed in houses having openings in the brick walls, leaving the lead to be exposed to the atmosphere.

"This is perhaps of more use in expediting the filling of the chambers with fresh air than in hiding condensation. Mr. Laird (a Glasgow manufacturer of the period) says that the hotter the chambers are kept the condensation is the more perfect.

"Each of these chambers has a valve, which is opened between the burnings.

"In them there is burned each week 1,386 lbs. sulphur, and 198 lbs. nitre, burnt in double pans, the larger above the lesser, and yielding 1,800 lbs. of o.v. of 1·8 sp. gr. (equal to a produce of 130 per cent. on sulphur, with 14·28 per cent. of nitre).

"Eight to nine inches of water on the floor of the chamber.

"The sulphur and nitre are mixed in the proportion of one of nitre and seven of sulphur.

"Of this mixture 8 lbs. are burned in each chamber every four hours. The mixture is burned on iron plates, or trays, of which there are two sets only in each chamber (more not being found so productive), each set consisting of two plates, one placed over the other about 3½ inches apart.

"The iron is of best quality and very thin, so that they heat quickly. They are supported in a frame, which can be drawn out at the door of the chamber.

"One pound weight of the mixture is put upon the lower plate, and three pounds on the upper plate.

"The plates being charged, the lower plates are first ignited, and when fairly lit, then the upper plates; the frame is then pushed into the chamber, and the door shut.

"The whole will be finished burning in one hour.

"Charge again three hours after the burning is over, or once every four hours, opening the doors and valves a quarter of an hour beforehand.

"The plates to be cleaned each time.

"By keeping this going on, they in six weeks made their o.v. attain a gravity of 20 oz. (1·250 sp. gr.), when it is run off for concentration to 22 oz. (1·375 sp. gr.), when it is used for bleaching liquors, etc., etc.

"Having six chambers, therefore, affords one for drawing off each week.

"State agreeable to the above—

1,386 lbs. Sulphur, @ £22, ...	£13	12	3
198 lbs. Nitre, @ £64, ...	5	13	1½
Labour, ...	1	1	0
Tear and wear, ...	1	1	0
	£21	7	4½
Off for drawback on Sulphur, at £6 12s. 8d. per ton, ...	4	2	0½
Producing 1,800 lbs. o.v., costing, ...	£17	5	4

"Equal to 2¼d. per lb., or £21 10s. per ton.

"Interest on sunk capital omitted in this state."

The prevalent theory held at this time may be seen from the subjoined note:—

"When sulphur is heated to 302°, it burns with a blue flame, and the produce is chiefly sulphurous acid.

"When sulphur is heated to 570°, it burns with a white flame, and the produce is sulphuric acid."

Numberless experiments were conducted with the view of being able to burn the sulphur at the proper degree of heat which should yield only sulphuric acid.

The fact that a quantity of nitrate of potash only equal to one-eighth of the oxygen required was sufficient for practical purposes seems to have given rise to the most extraordinary ideas at this time.

The following calculations give a good illustration:—

"100 of nitrate of potash, according to Kirwan, contains 41·2 of nitric acid, 46·15 potash, and 12·83 water.

"The acid of nitre consists of 7 of oxygen and 3 of azote, hence 100 nitrate of potash contains 28·7 of oxygen.

"100 of sulphur, it appears from Kirwan, requires 140 of oxygen to saturate it, or convert it all into sulphuric acid.

"100 acid, therefore, consists of 41·67 sulphur and 58·33 oxygen.

"Consequently 100 sulphur would require the oxygen of 525 of nitrate of potash for complete saturation.

"When, therefore, the maker of sulphuric acid adds 10 of nitre to 100 of sulphur, he has only 2·8 of oxygen, which will saturate only 2 of sulphur.

"Now, 10 of nitrate of potash contains 4·612 of alkali, that alkali is converted into sulphate of potash, and requires for this 4·5 sulphuric acid in that state in which it exists in the sulphate of potash (it contains, by Kirwan, 45 acid and 55 potash)—that is, the potash of the nitre takes more acid than is produced by the oxygen contained in the nitre, with its proper proportion of sulphur.

"The nitre, therefore, used in the manufacture of sulphuric acid, does not produce *any* acid which the manufacturer can be the better of. It produces no sulphuric acid in an uncombined state. The only other purpose it can serve is to produce such rapid inflammation of the sulphur as will be productive of sulphuric, instead of sulphurous, acid—that is, it produces a white flame, and the temperature of 570°.

"Even with nitre a great deal of blue flame is present, and consequently much sulphurous acid formed, and this sulphurous acid is all lost to the manufacturer, as it flies off in the operation.

"The manufacturer, at most, produces from 100 sulphur 168 of marketable oil of vitriol of 1·846 sp. gr.

"But 100 parts of sulphuric acid at this strength is equal to 89 at 2·000, which Kirwan calls his standard acid, and 100 standard acid is equal to 89·25 of acid such as exists in sulphate of potash, or 100 parts acid at 1·846 sp. gr. are equal to 78 as existing in sulphate of potash.

"The manufacturer, therefore, only gets 125·6 acid such as exists in sulphate of potash, whereas 100 parts sulphur should produce 240 parts of such acid, deducting 2 parts, which go to form the sulphate, leaving 238 parts.

"These 238 parts are equal to 290 at 1·846 sp. gr., which ought to be the produce, instead of 168.

"Hence only 55 parts of the 100 sulphur used to go to form sulphuric acid, and 45 parts are lost.

"Some part of this 45 may indeed be impurities—allow 5 per cent. on this account—still the manufacturer loses 40 parts in every 100 of sulphur.

"This 40 parts is converted into sulphurous acid and 5 lost."

The only way to prevent this is to burn the sulphur with a white flame, and by raising the temperature in which it is burnt to 570°.

At the Prestonpans works in 1800 they used per 112 lbs. v.g. o.v.—

100·8 lbs. Sulphur, at 7s., ...	£0	6	3
13·06 lbs. Nitrate, at 36s., ...	0	4	2
All other expenses,...	0	10	7
Cost delivered to purchasers, ...	£1	1	0

The selling gross price being about £60 per ton, this is equal to a production of say 198 per cent. acid, 1·84 sp. gr., with 13 per cent. nitre.

The size of these chambers was most likely the same as given in 1813, when they had 108 chambers, 14 ft. long, 10 ft. high, and 4½ ft. wide.

In 1805 a work existed at Burntisland which employed no less than 360 chambers, each 8 ft. long, 6 ft. high, and 4 ft. wide, containing 192 cubic ft. each. Water equal to 70 or 80 gallons (5 to 6 ins.) was run on the bottom, and the charge was 1 lb. of a mixture of 1 nitre to 6 of sulphur every four hours, half-an-hour allowed for ventilation.

The burning was continued for ten weeks, in which time 36 chambers yielded 60 bottles rectified acid—this being the weekly produce of the works :—

Produce, ...	173 per cent. o.v., 1·84 sp. gr.
Nitre, ...	166 „

Many more such details might be given, but it will be more instructive to trace the development of this manufacture in the progress of the St. Rollox Chemical Works.

These works were erected in 1799, for the production of bleaching powder, a patent for which had been secured by Mr. C. Tennant in the previous year. Considerable quantities of sulphuric acid were required for this manufacture, and were purchased from the various local makers from the Prestonpans Vitriol Company, and supplies were even brought from Halifax, the price at this time being about £60 per ton delivered.

The consumpt increasing rapidly, chambers were erected at St. Rollox in 1803. These were six in number, and seem to have been 12 ft. by 10 ft. by 10 ft., costing to erect about £50 each.

The house in which they were contained was of three floors, about 50 feet long by 24 feet wide. The upper contained the chambers, the next the glass retorts for concentrating the acid, and the lower the leaden evaporating boilers used in bringing the acid up to strength for the glass retorts.

The system upon which these chambers were worked was that as already described as in use by Messrs Bealy, and the quantity of sulphur burned was about 1,000 lbs. weekly, with about 14 per cent. nitre.

Various modifications of this system were tried, chiefly to improve the yield by charging less often, until the question of how to deal with the residues became a serious one, and in 1807 a third plate was added, on which the residues or "sulphur ashes" were reburned, mixed with a little fresh nitre.

This succeeded so well that considerable quantities of these residues were purchased from the other makers over the country, and used up in this way.

The sulphur ashes contained from 25 to 50 per cent. when only once burned, and cost about £5 per ton.

At the end of this year a brick furnace, heated artificially, was attached to one chamber, and in a short time two chambers were attached to one furnace, which was placed between them, and had a flue to each chamber.

The furnace burned the sulphur ashes, mixed with a portion of fresh sulphur and nitre. It worked almost continuously, the gas passing into one chamber for a certain time, the other meanwhile being shut off by means of a damper; then the first chamber damper was closed and the second opened. No. 1 chamber was allowed to condense for some time, and then the air valves and doors were opened to let in a fresh supply of air.

There were 14 chambers at work in this year, during which a produce of about 200 of acid, of 1·84 sp. gr., seems to have been obtained from 100 sulphur with 15 per cent. nitre. At the end of 1809 there were in operation 26 chambers.

In 1811, furnaces heated externally were applied to all the chambers, which were increased in number to 32, arranged in sets of two or three each.[*]

Sulphur ashes were used in large quantities.

The strength of the chamber acid, which had hitherto only been about 50° to 60° Twaddell, was gradually raised, and, steam having been introduced about 1813 or 1814, a strength of 100° to 120°

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[*] Red-hot plates of about a foot square and ¾ in. thick, in use generally by other makers.

Twaddell was attained, and the process became more or less a continuous one.

From this time till about 1840, the changes in the manufacture were chiefly in the direction of improving the form of the apparatus, both in chambers and furnaces. Pyrites were first used in 1840.

Communications with Hill show that he was using pyrites in 1820, in a chamber 50 in. by 26 in. by 22 in.; and Gay Lussac's method of recovering the nitrous compounds by absorbing them in strong vitriol in 1844, introduced by a Mr. De Courcy.

This was followed almost immediately by Mr. C. T. Dunlop's method of manufacturing bleaching powder by the decomposition of a mixture of salt and nitrate of soda, which gives off a mixture of chlorine and nitrous acid. The latter is absorbed in strong vitriol, and used as the source of nitrous acid in the chambers.

Various methods of denitrating this nitrous vitriol were from time to time tried, and the most successful perhaps, prior to the introduction of the Glover Tower, was a wall of coke extending across the chamber, through which all the gases had to pass, while it was kept supplied with nitrous vitriol at various points, so as to expose it in as thin films as possible. This method worked extremely well for many years.

The methods now in use in the manufacture at these works differ but little from the general system in use by the other large manufacturers of Great Britain.

The following list of vitriol makers in England is interesting, compiled in 1820—

Name.	Situation of Works.	Name.	Situation of Works.
Brundrum & Co.,	London.	Phipson,	Birmingham.
Farmer,	„	Paton,	„
Smith,	„	Bower & Sons,	Leeds.
Hill,	„	Norris & Son,	Halifax.
D. Taylor & Sons,	„	Betson,	Rotherham.
Liddiard,	„	Doubleday, Easterby,	
Dobbs,	„	& Co.,	Newcastle.
Skey & Beudley,	Staffordshire.	Rawson & Sons,	Bolton.
Caves & Co.,	Bristol.	Do.,	„
Bush,	„	Watkins,	Manchester.
Dobbs,	Birmingham.	Mutrie & Co.,	„
Austen,	„	Do.,	Whitehaven.

Twenty-three works in all at this date.

CHRONOLOGY—SULPHURIC ACID—GLASGOW, &c.

Works.	Date.	Number of Chambers.	Length.	Breadth.	Height.	Method of Burning.	Produce from 100 Sulphur, @ 1·84 sp. gr.	°/° Nitre.	Cost per ton.	Remarks.
			Feet.	Feet.	Feet.					
Mr. M——'s Business, -	1798	...	...	...	...	On Plates.	200 ?	28	£32	25 ton Sulphur; strength of Acid unknown; if 148° yield would be 200 °/°.
Bealy's, -	1799	6	12	10	10	Do.	130	14¼	£21 10/	Cottage roofs; run off each 6 weeks.
Prestonpans,	1800	108	14	4½	10	Do.	198	13	£21	Cost delivered to Customers; run off in 10 weeks.
Burntisland,	1805	360	8	4	6	Do.	173	16·6	...	Cost not known.
Nisbet, -	1805	...	..	...	...	...	187	25	£29	Small work.
A. W. & Co.,	1805	6	...	...	...	...	187	19	£28 15/	
W. N., -	1811	...	...	...	...	...	200	23	...	Sulphur Ashes re-burnt on red-hot plates.
Prestonpans,	1812	108	14	4½	10	...	220	Not known	...	Do. do. do.
Do., -	1813	108	14	4½	10	...	...	...	...	400 to 500 Glass Retorts at work, two charges per week; Chambers in 9 sets of 12 each, 1 set run off each week.
Kenny, Dublin	1813	2	45 25	17 17	10 20	...	...	...	...	
J. L——d, -	1813	...	...	...	...	...	200	20·8	...	
Camlachie, -	1820	...	...	...	...	...	263*	13	...	* Acid strength supposed to be 144° Twad.
Port-Dundas,	1824	1	70	18	...	...	246*	...	...	
St. Rollox, -	1803	6	12 ?	10 ?	10 ?	...	...	12	...	* Do. do. do.
Do., -	1806	...	...	...	...	...	185	12	£20 13/	
Do., -	1807	...	...	...	...	...	193	15¼	£18 15/	
Do., -	1809	26	...	No Record.		...	...		...	
Do., -	1811	32	60 ?	14 ?	12 ?	Furnace.	...	...	..	

I have now given you a hasty, and, necessarily, imperfect idea of the development of the sulphuric acid manufacture, from its small beginnings in glass vessels and earthen retorts up to the enormous chambers of the present day of a capacity of 60,000 to 100,000 cubic feet, and I trust that the subject has afforded you at least a passing interest. To myself it has much more than this, and the study of a gradual growth, as it were, of a little seed into the mighty tree, whose powerful trunk supports as its arms the general arts, and whose branches are laden with such varied fruits, in the shape of manufactured products, has to me a charm that calls forth both wonder and admiration.

X.—*On the Occurrence of Opal in the Colony of Queensland, and the Geological and Physical Aspects of the Country in which they are found.* By Jas. K. M. Robertson, M.D., F.G.S., F.R.G.S., Renfrew.

[Read to the Chemical Section, 23rd January, 1882.]

Very few of those to whom I speak on Queensland are aware that its surface area is about 8¼ times that of Great Britain, that 30 years ago there were not more than 1,800 white people settled in this vast extent of country, or that at present it can only boast of a population of 217,000, or rather less than 1 person to every 3 square miles.

The northern territory of Queensland is mountainous. It is covered by dense tropical vegetation, and is peopled by hostile tribes of aborigines. Of this region very little indeed of a positive character is known.

The east coast of the colony is fringed over its whole length by a high mountain chain, for the most part composed of granite. In parts these mountains are highly metalliferous—copper being extensively distributed around Mount Perry and Rawbelle, and at Copperfield; and gold, both alluvial and in quartz reefs, is found over the whole extent of these ranges. The principal gold-mining localities are—Gympie, in the south, around Mount Perry, Rockhampton and Morinish, Charters Towers, and Nebo, inland from Bowen; the Palmer and Hodgkinson districts, in the north; while in the mountain ranges that join the east coast with the Gulf of Carpentaria, the Etheridge, Hoolgar, and Gilberton gold fields have been opened up. In the far west the Cloncurry copper and gold fields (that I had occasion to visit) exist among the outliers of the M'Kinlay ranges, and from this field the richest ores of copper and the finest gold in all Australia is obtained.

Queensland minerals are all of a high order, in respect to quality and productiveness, but, up to the present moment, they have not received that attention from capitalists that they deserve. Its quartz reefs carry a higher average of gold than any in Australia, yet, from the rudeness of the manipulative processes, and the perfunctory methods of mining practices, their working has not been attended with the success that better systems would have ensured. I am pleased to be able to make an exception to this general statement in favour of Charters Towers and Gympie, where several complete recovery plants have of late been erected.

The coast ranges rise to an average altitude of 2,000 ft. From this elevation plateaux or tablelands extend inland. The granite formation has been pierced by great belts of volcanic or intrusive rocks, and very large areas of these tablelands are covered by slabs of vesicular basalt in process of decay—the decomposition giving rise to deep black soils. It is a curious circumstance that these basaltic blocks are confined to the top, or seem to float upon the surface of the soil—the soil underlying them being entirely destitute of stones. Other portions of the plains are composed of chocolate-coloured or red soils, resulting from the decay of intrusive rocks containing iron. Further inland, these black and red soil plains give place to extensive downs, composed of deep, darkish-grey soil, overlying rocks, evidently of oolitic or cretaceous age, and exhibiting in parts a peculiar cone-in-cone structure. All these plains are covered by a great variety of the most nourishing and permanent grasses. These plains over several degrees of latitude and longitude are perfectly level, and for the most part are featureless and destitute of trees, and innocent of roads or tracks. Over them the traveller rides—often guided by the compass—with no landmarks or milestones to relieve the tedium. He looks constantly over an apparently illimitable sea of luxuriant grass.

In the morning he sees the sun rise out of the grassy sea; he watches it ascend into the blue vault of a cloudless sky, again to set with gorgeous splendour to illuminate a similar expanse of verdure.

From the Gulf of Carpentaria a midrib of hill ranges run south through the continent: 250 miles south of the gulf the M'Kinlay ranges branch off to the east; and from these, ranges run south to form the Grey Coleman, M'Gregor, and Cheviots, that determine the several water-sheds of the interior.

The southern division of Australia, bounding upon Victoria, New South Wales, and South Australia, is more park-like in character than the central division just referred to. A large portion of it is covered by stunted trees, or a scrub of peculiar description—its stunted character being due, no doubt, to the uncertainty of the seasons and the protracted droughts to which this part of the colony is subject.

The country is covered by recent rocks, chiefly of soft, friable, unbedded sandstones and indurated clays. It is intersected by low ridges or belts of porphyritic or quartzose rocks. On one of these hard vitreous ridges I noticed a rather curious circumstance. On the very apex of the flinty ridge, with a perfectly arid landscape all around, the savage natives had dug, at a great expenditure of labour—very possibly with rude stone implements—three small holes or native wells. In these wells water is at all times found, and they have never been known to overflow. They have possibly been sunk upon some small crack or fissure that exudes water.

The river systems of this part of the colony are peculiar. In the dry season they appear to be composed of connected lines of water-holes, known as "billabongs." During times of drought these are so many reservoirs for the storage of water; but during the rains they overflow, and are often 20 miles broad. Such are the Maranoa, Warrego, Paroo, Bulloo, Blackwater, and Cooper's Creek river systems.

The stunted scrub that covers large areas of country is called mulga. Its leaves are small, fleshy, unctuous, and lanceolate, and of a dark olive-green colour. Where the soil is particularly deep and rich, open plains occur, that, while moisture remains, are covered with abundant and luxurious grasses. This is the principal cattle-rearing district of Southern Queensland, where great mobs of bullocks roam at will "on a thousand hills and bosky dells," living solely on the grasses and nutritious shrubs that abound, until they are collected and travelled for hundreds of miles to the Adelaide and Melbourne markets.

The district is subject to droughts. It was near to this that the explorers, Burk and Wills, with their party, perished many years ago. When I rode through it in July of last year, not a drop of rain had fallen for over 22 months, and then there was no sign of a change. The grass during such prolonged droughts gets scarce and burnt up, while incalculable quantities are annually consumed by bush fires. At these times cattle enter the mulga scrub and live and fatten upon the leaves, travelling once a-day to the nearest water-hole to slake their thirst, or they feed upon the cotton or salt bush that, instead of grass, covers some of the plains.

Very few marsupials are found in this region; their numbers are probably kept down by the swarms of "dingoes," or native dogs, that abound. To cattle these dogs do little damage, but among sheep they cause such destruction that squatters systematically poison them with strychnine. After nightfall the discordant howl of these pests, around the camp fire, is quite loud enough to awaken anything human, save the easy-minded bushman, who, exhausted by a long ride, has rolled himself in his blanket, and, with his head on his saddle, has shut his eyes on the twinkling constellations, and with half open mouth is snoring in a manner that speaks volumes for the simple diet of bush life, and the invigorating freshness of the air.

The climate is salubrious and healthy. During the summer months of November, December, January, it is hot, but dry, the thermometer averaging 105° to 110° in the shade. The rainy season occurs, as a rule, in February, when a large part of the country is under water. During March, April, May, the air is cool, the skies clear, the mornings cold, and the surface of the earth covered with flowers and verdure. In June, July, and August, the days are bright and cool, the nights being cold, or frosty. September and October are the spring months, when the temperature increases, and showers freshen the parched earth. In the pure atmosphere of these regions there are no febrile ailments, and little disease of any description, save the lesions, and the drivelling idiotcy, caused by drinking "doctered rum" or 1-star brandy, at 17s. 6d. per bottle. However excellent the breed of cattle or sheep may be in the colony, there can, I think, be little doubt that its present tendency is to breed a most depraved and demoralised variety of the genus homo.

We had for days been riding through a broad belt of rough and disconsolate scrub, breathing an atmosphere of pulverulent dust; but, after crossing the Gray range, we enter a broad expanse of green and grassy downs. Breathing the ethereal and invigorating brilliance of the dry air, our spirits rise, and we strive to forget the rough usage, the forbidding desolation, and the dust of the past week—borne, as we suppose, with exemplary fortitude and Christian forbearance. The silence is profound. As we ride onwards the feeling increases that, as far as the absence of life, or habitation, or occupation, is concerned, I might be

"... the first that ever burst
Into that silent sea."

Behind us the higher eminences of the Gray range rise as out of a cloud of gleaming vapour, and these, from their appearance, are known as the *Hay Ricks*. Around us detached squadrons of emus run in uncertain lines; and before us—over a sea of verdure—is the mirage of a great lake. We cross stony ridges, or belts of vitreous and highly transmuted siliceous rocks, over which our unshod horses walk warily; and once again we cross the grassy plain, bearing almost due west. Water is scarce. Sometimes spaces of 25 miles separate the water holes. In some of these liquid is seen resembling in colour and consistency thin white paint, and this decoction is imposed upon strangers as water. It tastes strongly of "cow."

We cross salt bush plains and belts of flaggy sandstones, and *at last*—above the horizon—the peculiar outline of the ranges, near the locality where the explorers, Burk and Wills, perished, rise into view, and lends variety to the scene.

Next morning we collect our shivering horses by moonlight (the grass and ground being covered with hoar-frost and the pools with ice), and ere tbe orb of day had arisen we were threading a devious way over frightfully stony ridges, and through thick, prickly scrub, that tears the emblems of our civilisation and scratches our faces, to emerge from it in a condition of doubtful respectability. We ascend a range composed of gritty sandstone, with slopes covered with fallen blocks and decaying fragments, piled up in chaotic confusion. Some of the hill masses are of blood-red colour, and exude salts of magnesia. Some are olive-coloured, or ochrey yellow; some resemble bathstone; some are a blending of all these. The lithological character of these rocks are by no means distinctive, but they are evidently of tertiary age. Porphyritic dykes traverse, but do not appear to disturb, the rocks. High overhead are crumbling cliffs of mottled sandstone of curious outline. Around us the heat quivers in the air, and against their mural sides the bright sun dances with a fierce delight. By dangerous paths we continue to ride up the slopes of these fantastic-shaped hills, and by some unaccountable accident arrive in safety at the top.

Not a sound, save the panting of our horses, disturbs the solemn and all-prevailing silence. We are alone with nature, in the centre of a great continent, and we feel that he indeed must possess a dull and incurious mind who is not impressed by the singularity and the charming loveliness of the scene. Twenty miles off, across a grassy and park-like plain, the Coleman and M'Gregor ranges rise, clear and distinct, amid the flood of light. The outline is wonderfully lovely. In the foreground a number of cone-like and castellated hills of all colours rise from the plain, the more connected ranges of the background appearing as if capped by numerous and enormous fortifications. Some of the isolated conical hills terminate in sharp apexes or spikes, others terminate with flat circular crests and perpendicular red sides, rising out of slopes of yellow or reddish earth, partially covered by struggling vegetation. The whole of these hills have approximately the same level or elevation—their contour being entirely due to the effects of climate operating over incalculable periods of time. I have endeavoured to represent the outline of these hills in sketch No. 1, but I regret that I cannot convey to you any idea of their aspect as I saw them through the clear ambient air, rising out of a carpet of green, with the sun to illuminate them, and distance to soften and to heighten the effect.

Similar country—geologically—extends through about three parallels of latitude and about two of longitude, and within this area siliceous minerals, such as quartz in various forms, agates, chalcedony, cornelian, and opals, are found. With the latter only I propose to deal.

These rocks are evidently of tertiary age, but they possess no very distinct or typical characters. The component parts are gritty sand or earth, the bedding is obscure or false, and the colour is apparently due to the admixture of protoxide of iron in varying quantities. The colour is, however, striking—blood-red, grey, brick-red, cream-colour, olive, yellow, or mottled. These colours may, within a few yards, insensibly blend into one another, or they may be separated by a distinct and sharp line of demarcation, as in the specimen that I now show you.

In certain parts these loosely aggregated sandstones are held together (as are the great sandstones that overlie the coal formation of N.S.W.) by irregular mahogany-coloured ferruginous bands. These segregations of iron have, in some parts of the district, formed fissures within themselves, and into these crevices a fine siliceous fluid has been introduced, and become consolidated. In other localities where the necessary conditions have been present, these siliceous threads have become opalised, and where these have absorbed infinitely minute traces of nickel, or manganese, or iron, or all three, they exhibit all the lovely play of colours distinctive of the precious or the fire opal. The specimens will serve to illustrate this condition.

Again, while some of the more aluminous beds have been subjected (we shall suppose) to the influence of heat, the plastic matrix has been rendered vesicular, and a number of the cavities so formed have, by subsequent infiltration, been filled by silica, which has become opalised. Specimens labelled No. 17 illustrate this condition.

Again, as we approached the margins of this district, we passed over certain beds of indurated and transmuted schists, and in these small nodular concretions of siliceous ironstone can be picked out. These little flattened spheres are about 1 inch in diameter. On breaking them numerous minute crevices are seen to radiate from a centre, and these hair-like fissures have been filled by a plastic mass, which has become opalised, but of no value whatever. In the reniform nodules of C.B. ironstone that are found in the clays, or in the soft shale beds of our coal measure, identically the same appearances are to be seen—only, in the latter case the septaria are filled with ordinary quartz.

Approaching the main ranges, almost every other ridge is covered with splinters of a milky or opaque variety of opal. Specimens Nos. 1 and 5 illustrate this and the last-named variety of opal.

Without going more into detail, I must ask you to believe that it is only within a certain very small area of this extensive opal-bearing country that opals of any commercial value have been found. I feel that I need scarcely mention that opal is a siliceous mineral—an analysis of precious opal showing 90 $^{\circ}/_{\circ}$ of silica and 10 $^{\circ}/_{\circ}$ of water; that it is considered an unlucky stone by ignorant and superstitious people; that its beautiful combination of colours probably depends upon the presence of exceedingly minute proportions of some colouring matter, such as those produced by iron, nickel, or cobalt—the colour being intensified by the presence of numerous invisible fractures.

I may inform you that over very large tracts of country in the lower Bulloo and Barcoo districts, opal is found filling the narrow and irregular fissures of a ferruginous matrix, or in delicate scales, so thin that they appear as if painted on to that matrix. But these, however beautiful, cannot be utilised by the lapidary. See specimens 3 and 4.

The comparatively small area within which opals of commercial value—that is, in respect to quantity, colour, and thickness—have been found, consists of castellated sandstone hills of curious configuration. In sketch No. 2 I have attempted to delineate the physical features of the two hills under which the best opals have been found. These hills, with their mines and openings, will hereafter be designated Aladdin. As in certain localities minerals occur in certain distinctive forms, so each locality that I have named can at once be distinguished by the characteristic form of its opals.

Instead of the thin, thread-like, or scaly patches that are found in the liver-coloured matrix of the Bulloo or the Barcoo country, it is found in the Aladdin hills, in all its most valuable and lovely forms, as precious opal, as fire opal or girasol, as common opal, as wood opal, and as hyalite. At Aladdin it is found under the following conditions:—

First. Masses of laminated ferruginous silica of some thickness are found embedded among the gritty sandstone beds, and these masses are occasionally divided into squares by comparatively wide fissures. When broken, some of these pieces are found coated with a layer of opal from $\frac{1}{8}$ to almost $\frac{1}{4}$ of an inch thick. The opal is arranged in bands of brilliant emerald green, or bluish-green, yellow, or red. I show you, in specimens No. 7, two large pieces coated with opal on three sides, which, for beauty, can scarcely be surpassed.

Second. In the country immediately adjoining Aladdin hills large quantities of opaque opal or chalcedony is found. Nearer

Aladdin this variety is found in a more refined and translucent form, showing a little colour, as in specimen No. 2.

The Aladdin opal is found on the slopes of the two hills referred to. These hills rise out of a level, grassy, or scrubby plain. The slopes are composed of loose, decaying pieces of soft sandstone. They have an angle of 45°. The top is of a concretionary mass of gritty, loosely-aggregated sandstone, full of adventitious or accessory pebble and minute holes. The colour is reddish or mottled, and is due to the permeation of ferruginous waters. The crests are redder than the underlying portions, and resemble badly-burnt brick in appearance and consistency. The top of one of the hills is circular, the other is elliptical, and is several hundred feet in length. The crests are divided by vertical joints formed during consolidation, and have broken off by these, forming the perpendicular walls, and producing the castellated appearance referred to. The strata underlying the crests is composed of soft grey or yellow earthy layers, closely resembling bath-bricks, obscurely bedded, difficult to correlate, broken up by vertical joints, and held together by irregular strings of ferruginous sandstone.

Third. At intervals, soft and somewhat irregular or strangulated beds of steel-grey or chalky earth, about eight inches thick, separate these beds, and embedded in this chalky earth flattened nodules, or lenticular masses of what I supposed at first sight were ironstone, are found. These nodules are of very uniform size and shape—about 10″ × 6″ × 5″. They are found lying on their flat side. As these nodular masses are the principal source of opals, I would desire to describe them somewhat in detail. Diagram No. 1 is a front view, and No. 2 represents a section of one hill, and No. 3 an enlarged view of a bed, illustrating the occurrence of the nodules. These nodules consist of an external crust or shell, the thickness varying from ½″ to 1″. This shell is built up of a number of thin concentric layers of ferruginous silica, separated by finer lines of a light yellow colour. On being broken, these concentric layers are seen in section to enclose a siliceous, somewhat splintery, cream-coloured kernel, that completely fills the shell. These kernels are the *real* matrix of the opal. During the process of drying and consolidation, cracks and cavities have formed, separating parts of the kernel from the shell, but invariably reticulated throughout the mass of the kernel. In the same manner septaria (fissures and spaces) have formed in the substance of the hard shell—seldom, however, penetrating through all the layers. These vermiform crevices or septaria have subsequently become filled with a plastic or gelatinous solution of silica, which has become opal, the quality evidently being dependent on the degree of compression, or the variety and amount of the colouring matter absorbed, and the presence of other conditions, to which I will afterwards allude. I have remarked that the nodules are found lying on one of their flattened sides. Now the thickest and best opal occurs as a rule, but not invariably, on the lower surfaces, where, from gravity, you would suppose a fluid would accumulate. The crevices or septaria occurring in the shell frequently exhibit opal, that emits rays of blood-red or emerald-green colour. Where the particles composing the shell have been loosely aggregated, silica has been absorbed, and the substance of the shell itself has become opalised.

The question naturally arises, From whence and in what manner were these nodules formed? Arranged, as the shell is, in layers similar to an agate, one is inclined to think that their origin is due to the infiltration of siliceous waters into a cavity, but the similarity in form and size, and arrangement in beds of these nodules, opposes certain difficulties. If we adopt this view, we must account for the white kernel within the shells.

If the shells have *not* been formed within a cavity (and I am inclined to think they have not), they may possibly owe their origin to segregation alone. The kernel is composed of material more compact and siliceous, and contains less iron than the superincumbent strata. If one could imagine the iron or colouring matter abstracted from that strata, while the mass was in solution, the resultant would, I think, present an appearance very much akin to these kernels. As to which of these causes, if any, their origin might be due, I am not prepared to say, but I have laid out several forms of these nodules for your inspection, along with about 110 illustrative specimens, as I took them from the mine, that you may be enabled to form some independent opinion on the subject.

To my mind the origin of the opal itself is not veiled in so much obscurity. On minute inspection I found that the soft earthy superincumbent beds contained curious vertical rods of ferruginous silica, similar to the shells of the nodules. These rods appear to lead from the layers of nodules up through the superincumbent rocks. On breaking one of these rods out, I found that in reality it was a pipe, containing, within siliceous walls, a small round channel. I show you such a pipe, No. 13. The first of these that I picked out were either empty, or contained a little powdery earth, and I at once recognised in them a clue to the formation of the opal, if not the nodules themselves. While prosecuting my investigations among the shattered fragments of a recently fallen cliff, I came upon additional bits of these fractured pipes, with the channels filled with opal. I have laid out several fragments of these pipes, with the channels filled with opal cores, No. 12. One or two of these cores, in specimens No. 19, display throughout their whole body the wonderful and delicate play of colours characteristic of the Oriental opal. There can, I think, be little room to doubt that the matter that formed the opals, in the kernels described, was conveyed down through the mass of rock by means of these pipes, but whether these fulfilled the double purpose of conveying down the substance of the nodules themselves, as well as the opal, and whether these were synchronous or separated by a period of time, must be left for future investigation.

So far as I could discover, there are several layers of these nodules underlying—interstratified, if you will, with sandstone—the Aladdin hills. These beds or layers are separated from each other by several vertical feet of strata. The nodules are not all uniformly charged with opal; some are of little value, others contain opal of great value. The most valuable stones are broken by the act of smashing the nodules. As there are no outward signs by which the opal value of the nodules can be determined, each should in future be sawn across, in order to discover the quantity and quality of the contained gem.

To the right of diagram No. 3 is an enlarged section of a nodule showing the mode in which opal is found within its kernel. The pipe that I have sketched must be considered imaginary, as I have not been able to trace such a clear connection as is here shown. Those of you who know the sequence of the chalk formation will recognise in the occurrence of the nodules a close analogy with the layers of flints found in some districts where chalk is found.

Fourth. I have on more than one occasion remarked that the crests of these hills assumed a castellated or turret form, and were composed of gritty, ferruginous particles of brick-like consistency and colour, and that it was somewhat porous. It has all the appearance of having been subjected to heat and given passage to heated gases. In examining this sandstone I found the remains of pipes or vertical channels, with obscurely-defined walls, filled with common and precious opal, or opal having a burnt, waxy, vitreous appearance. Opal is found in this sandstone occupying holes or cavities, or filling up portions of the mass where the sand has been loosely impacted. Portions of the substance of the sandstone have, in fact, become opalised. You will find specimens on the table illustrating this condition.

In the gritty, brick-like crest opal is found of beautiful colour, in irregular shoots, among the matrix, or permeating the substance of the matrix. (Specimens No. 10.)

So far the result of my investigations go to prove that the origin of opal is due to the infiltration of opal-forming material (siliceous waters) from above, and that the subsequent elaboration, or the formative process, has been encouraged under conditions of pressure and heat, both of which I believe to be favourable, if not necessary, for the solution, separation, and ultimate crystallisation of the silica that in so large a measure forms the opal.

These latter conditions, mark you! I have *not* established so fully as I could desire, but this I can say, that the two Aladdin hills are separated from each other, and are situated between three broad intrusive dykes of compact grey and vitreous *felsite;* further, that the indurated clays are burnt in places, and bear evidence of having been subjected to a high temperature; that portions of the sandstone bear similar evidence; and that the finest quality of opal is, as a rule, found within a reasonable distance of these "dykes."

Nor have I been able to determine whether or not the gem exists in like conditions under the level of the surface. There can, however, be no doubt that from all these sources large quantities of opal will be obtained.

Whatever be the extent of the resources in depth, or the exact conditions favourable or necessary for the development or formation of the opal, all evidence seems to point to the *localisation* of these conditions—in other words, that valuable deposits of opal are *not* widely distributed.

I have stated that the occurrence of these nodular masses inclined me to the belief that their origin was due to segregation, and that it was probable that the opal found in the septaria, or filling the fissures of these nodules, was due to infiltration. I wish you to clearly understand that this is only an opinion. I cannot say that I have established it even to my own satisfaction.

My opinion is based upon finding opal in various forms within the channels of the vertical pipes, as may be seen in the several specimens laid out for your inspection. It may be held by some of your number that opals, as well as the "casing" or shell of the kernel, have all been formed by *segregation*, and that the *pipes* are due to the same cause. Dual segregation in the one case, and the fact that the channel within the *pipes* is sometimes empty, present to my mind certain difficulties to the acceptation of such a cause. Still I am not prepared to negative it.

It may be permissible to say a few words upon the nature and origin of the material that has, by subsequent agencies, been converted into opal. It is very probable that the material was derived from above, and from the rocks in which it occurs. Opal, as you are no doubt aware, is an amorphous, and one of the many forms of quartz. Roughly speaking, it is composed of 92 of silica and 8 of water, with certain colouring agents. You may consider opal as a solidified mass of gelatinous silica, in which the proportion of silica and water varies. You may recollect that, when describing the nature and colour of the rocks composing the hill ranges, I remarked that the surfaces of the rocks were occasionally coated by an efflorescence of magnesia salts. It is probable that the constituents necessary for the formation of opal may be obtained from the decomposition of the silicate of magnesia by carbonic acid. Causes that would at first sight appear to be trivial and unimportant, are often sufficient to cause silica to pass from one condition to another—from the amorphous to the crystalline state. The presence of carbonate of ammonia would be sufficient, under certain conditions of silica, to precipitate silica and alumina; and ammonia may be produced by the presence of some nitrogenous organic substance in the solution of silica. You are probably all aware that many of the forms of silica do contain an organic substance, and this is proved by the change of colour that they undergo when subjected to heat. Chalcedony, rose quartz, cornelian, smoky topaz, are examples of this condition. Probably the reason why opal is an amorphous, and not in a crystalline form of quartz, is because of the presence in it of iron or manganese.

The amount of water contained in opal varies considerably, from 3 °/o to 10 °/o. Opal differs from quartz in having a lower specific gravity, and an inferior degree of hardness in refraction, and, of course, in chemical properties. The beautiful combinations and play of colours exhibited by opals are probably due to the colouring ingredient present, and these may be influenced by the presence of some invisible flaws. The colours are intensified by heat and light.

Some observers affirm that the distinct bands of some varieties of opals are caused by infusoria, and that the red fire of the noble opal is caused by the presence of minute particles of quartz.

In Hungary and elsewhere where opal is found, the gem is found in trachyte, and is considered as the result of the decomposition of that rock. The presence of siliceous rocks may be considered as essential to the formation of opal, and like all mineral substances derived from adjoining rocks, it bears a definite relation to the constituents of the rocks from whence, by decomposition, it was derived.

Dr. Dobbie of this Society has very kindly furnished me with an analysis of the opal of Aladdin; of the ferruginous crust of the nodules; of the white matrix or kernel within this crust; of the rock in which these are found. And these are as follows:—

I.—OPAL.

Water,	6·43	per cent.
Silica,	93·57	,,
	100·00	,,

II.—WHITE KERNEL.

Sesquioxide of Iron,	2·15	per cent.
Sesquioxide of Alumina,	30·94	,,
Silica,	67·31	,,
	100·40	,,

III.—FERRUGINOUS CRUST OF NODULE.

Silica,	35·89	per cent.
Sesquioxide of Alumina,	2·99	,,
Do. of Iron,	47·72	,,
Protoxide of Iron,	3·55	,,
Lime,	·46	,,
Magnesia,	·55	,,
Water,		,,

IV.—SANDSTONE OF HILL.

Silica,	65·94	per cent.
Sesquioxide of Alumina,	13·54	,,
Do of Iron,	14·04	,,
Lime,	1·03	,,
Carbonic Acid,	·37	,,
Water,	1·03	,,
Alkalies by difference,	3·88	,,
	100·00	,,

In the flats immediately surrounding these remarkable hills are several circular mounds, evidently marking the site of other conical hills slowly settling down under the influence of the climate. The earthy portion has all been washed away into the plains; the ferruginous nodules have been broken up by the powerful rays of the sun, the rains, and the winter frosts. Amid the wreck of materials one has no difficulty in picking up pieces of opal, weathered by the sun rays of a thousand summers, and bushels of matrix or shells may be gathered with the substance, a net-work of brilliant green threads of opal, which, when cut and polished, might be utilised as buttons or breast-pins, or for inlaying, or other useful ways. (Specimens No. 19.)

I have taken up much of your time, and probably have succeeded in exhausting as much of your patience, in describing the details of the occurrence of opal in Central Australia. My apology for so doing rests in the circumstance that I have not been able to discover any work in which the occurrence of these gems are minutely described. Dana states that in Hungary, Bohemia, Saxony, Mexico, Iceland, opals are found, and that in these countries they are "found filling the cavities or the seams of igneous rocks, or, like other quartz concretions, embedded in flint and limestone." The description is certainly vague, and he might have added Brazil, where it occurs in connection with transmuted limestone, or in crevices of altered chalk. So far as I can discover, Australian opals will in the future be more heard of. They occur under totally different conditions to those he alludes to, and to all appearance in quantities that, should the gem become as popular as from the beauty of its hues it deserves, these lonely wilds of Central Australia will be the scene of an industry as lucrative as it is novel.

The recollection of the magnificent view from the top of the Aladdin hills comes back as a green and pleasant reminiscence of a long and wearisome journey. Though there is no soil on the top, a few stunted honeysuckles and hardy flowering plants have struggled into existence to "waste their fragrance on the desert air." Among these we sit to scan the illimitable landscape, and to watch the sun set in an atmosphere of roseate glory. We see the light stealing over the plain, colouring the scrub and illuminating the curiously-shaped hills with golden hues. It vanishes from the plains to play among the lesser hills—wonderful effects of light and shade are visible. Mounting upwards bands of coloured rays are projected against the crests of the higher peaks, that shine for a moment like burnished gold. While yet the soft and short twilight of these regions lingers on the mountain slopes, and the valleys are in partial darkness, we seek the genial warmth of the camp fires, and the comfort of the "cup that cheers but not inebriates," and rolled up in our blankets we fall asleep under, may I say, the shadow of the Southern Cross. At an early hour we had turned our back on these quiet and sunny scenes, and, with our saddle bags heavily laden with the spoils of the Aladdin hills, we jog steadily back on our long journey of well-nigh a thousand miles towards Brisbane and the rising sun, meditating all the while on a further journey of 13,000 miles, through the land of the "Spread Eagle," towards home and friends. I did not at that time anticipate that I should so soon after my arrival have the felicity of appearing before the members of this Society to dilate, as I have done, at no inconsiderable length on the physical geography of part of "Greater Britain," the land of the wallaby and the kangaroo, and the geological aspects of the opal country of Central Australia.

XI.—*Opening Address to the Architectural Section.* By James Sellars, Jun., I.A., President of the Section.

[Read before the Architectural Section, 28th January, 1882.]

In occupying for the first time the President's Chair of this Section, I desire to express my sense of the honour which you have been pleased to confer upon me.

Remembering the long list of honoured names which have been associated with this Chair, I accept the position with diffidence and a deep sense of responsibility, and bespeak your kindly forbearance and support while I endeavour to fulfil the duties I have undertaken. Our Society has a history. More than twenty-five years ago it was in active operation as the Glasgow Architectural Society. Under this name it did good, useful work for many years, but, on the formation of the Glasgow Institute of Architects, it was thought desirable for many reasons—among others, economy in management—to carry out the arrangement whereby we became a section of the Philosophical Society. We are, however, although different in name, the same Society, having the same objects, and carrying on the same work, so well begun a quarter of a century ago by men whose example we desire to follow and whose memory will ever be respected in our profession.

Since we entered on this new form of life the work has been carried on more or less vigorously, and on the whole I think we may fairly congratulate ourselves on the work which has been done, and the prospects for the future. But, while I think we have done much in the past, I am far from believing that we are as a Society as healthy and vigorous as we ought to be. As we draw our members from the ranks of all the professions and trades interested in building, our membership, instead of being limited to about 60, ought to be four or five times that number. I find from the Annual Report of the Glasgow Architectural Society for 1861—of which, as I have already said, we are the direct descendants—that at that time they had 144 members on the roll, showing a much healthier condition of things than we can boast of now.

This is rather a disagreeable fact, but I cannot refrain from bringing it before you, and I appeal to the hundreds who ought to be amongst us to lend their aid, by becoming members and reading communications, to increase and extend the usefulness of the section; and I appeal specially to the members of my own profession to join us in larger numbers. It is true that we have our own Institute, but that body deals with purely professional matters. The Institute is admirable for its purpose, but it gives no opportunity such as this Society does for the discussion of popular subjects, interesting alike to the architect, measurer, builder, and the public. At our meetings here every question connected in any way with the science and art of housebuilding may be dealt with, and there can be no better arena in which to discuss architecture in its artistic, scientific, practical, or sanitary aspect. For, besides the fact that our section includes members of all the branches of the building trade, our connection with the Philosophical Society is a great aid in giving publicity to our views.

As regards the importance of having such matters discussed, I do not think there can be any question. There is hardly any subject in which the public take such a warm interest as the arrangement of the houses in which they live, of the office or the warehouse in which they perform their daily work, or of the places where they resort for amusement or instruction. Their comfort and their health are affected for good or evil by the kind of building in which they sleep, work, or play, quite as much as it is by the kind of food they eat, and nothing can be more important than that all these places should be artistically and practically fitted for their purpose. The designing and construction of these buildings is, or should be, our joint work, and, as labourers in the same field, it cannot be otherwise than beneficial that we should meet together for the interchange of ideas and the discussion of points of difference, and thus, as I believe, raise the general standard of excellence.

In every condition of life people are more or less dependent on each other, and I think we, the architects and builders, are specially so. It is not with the architect as with most other professional men, or skilled workman, who begins and ends his work with his own hands and brains. With him the realisation of his thoughts has to be done by other hands. He may prepare his plan carefully in all its details, and delineate it fully on paper; it may give promise of a perfect structure, but before it can be realised in the enduring stone he is dependent, to some extent at least, on the skill and intelligence of his fellow-workers.

I think I have said enough to show that, in my view at least, the usefulness of this Society might be greatly extended, and much mutual benefit obtained, by a largely increased membership, drawn from all the classes interested in the building trade.

I do not propose to occupy your whole time with the consideration of any one subject, but rather that my remarks should be suggestive of subjects for future discussion.

If I were the president of a purely scientific body, like some of the other sections of the parent Society, I would probably be in a position to direct your attention to some new discovery during the past year connected with the branch of work in which we were more particularly interested; but, while I am not able to do so, because the science and art of building are about as old as history itself, there are several subjects of more than passing importance which may very well engage your attention, and regarding which the members of this section are well qualified to express an opinion. Among others, there is the question of building regulations for house property, and the arrangement of dwellings of the industrial classes. This subject has, it appears, engaged the anxious attention of the public authorities for a long series of years; and that it is a question urgently requiring attention cannot be disputed. Hear what Dr. Russell, the able Medical Officer of Health for Glasgow, says as to the position and kind of houses occupied by the working classes:—

"What does it (that is, density of population) mean in Glasgow? It means, to begin with, an area of 6,033 acres, surrounded, not by open and thinly-populated country, but by a dense population, on some 4,700 acres of which are congregated about 566,000 human beings, with thousands of the lower animals. It means that three-fourths of these human beings live in a house of one or two apartments; that their houses are built in tall tenements, so arranged on the earth's surface as to exclude the sunlight and to impede the circulation of the air; more especially that a large proportion of these tenements are arranged in hollow squares, which are boxes of stagnant air. It means that inside these boxes there are ashpits and privies, the superficial area of which, at a moderate computation, is 4½ acres; that, planted among these ashpits, we have hundreds of back lands, along with stables, byres, bake-houses, workshops, washing-houses, and other smoke and effluvia-producing erections; that the stairs are often close and badly ventilated; that they are at best vertical streets, with lanes and alleys branching off at the several landings; that houses in flats, planned for occupation by one family, are occupied by several families, each renting one or two rooms; and the lobbies dark and tortuous by which they reach the stair. It means that a large proportion of the inhabitants are dirty in their persons, dirty in their clothes, bedding, and houses; that the atmosphere is vile, and the air in the lobbies is common to everybody living in the houses and using the stair; that the courts and back areas are full of impurities, animal and vegetable, and are only kept tolerably decent by the daily service of the public scavengers. It means that the mass of our excretions is so enormous, in relation to the earth and air space, that to get them removed from our houses and precincts water carriage must be employed, and therefore our rivers and streams are loaded with the foulest refuse; that the subsoil is traversed with a network of sewers, drains, and gas-pipes, and is therefore so impure that the ground air is loaded with noxious effluvia, and the ground water is so foul that to drink it would be poisonous. Finally, we are as far shut out from the ministry of nature as the necessities of the case, combined with the aggravations of human ignorance, perversity, and wilful self-aggrandisement can place us."

I have been tempted to make this somewhat lengthy quotation, believing that no one is in a better position than Dr. Russell to describe the condition of things as they are—no one better able to paint the picture of the discomfort and dirt which are in our midst. It may be that the drawing of the picture is too forcible, that the colouring is too strong in parts; but, on the whole, it must be pronounced a true representation of the case. It is little wonder, then, that the mind of our authorities is exercised on the subject, that we hear of great sewage schemes in the near future, and "Provisional Orders" "to control in an adequate and satisfactory manner the erection and alteration of buildings within the city and burgh of Glasgow, so as to secure sufficient free space externally and internally, and sufficient light, ventilation, and drainage connected therewith."

A provisional order, containing amendments on some of the clauses, relating to building regulations, of the Police Act of 1866, was applied for in 1879, and although Sheriff Clark, while approv ing generally of the scope of the proposed order, and believing that the principles embodied were sound, was unable to recommend its adoption—chiefly owing to certain regulations which were held to amount to confiscation of property—there is not the least doubt that some steps must be taken, and that before long, to amend the law which permits such a state of things to exist as to justify the appalling picture delineated by Dr. Russell. The learned Sheriff, after conducting a most exhaustive inquiry into the proposal contained in the provisional order, said, in his report to the Home Office:—"The sanitary condition of the city of Glasgow is at present such as plainly to call for and warrant regulations of a much more stringent kind than those now in operation. Provisions are required to secure better ventilation, greater access of sunlight, and more free space both in and about the blocks of buildings. More effectual means are also necessary to enforce proper drainage." The details of this order are well known to most of you. A record of the whole proceedings before Sheriff Clark is in print, and it forms a most interesting volume indeed, containing the opinions, as given in evidence, of many of those best able to speak on the subject.

Whatever difference of opinion may exist as to the way in which the authorities proposed to effect their purpose, there can be but one opinion as to the practical good which would have resulted from the adoption of the provisional order. This is, of course, apart from any question of compensation for interference with vested interests. Now, as regards this question of compensation, while I think private interests in some circumstances ought and must give way to the public good, the authorities—if they believe that certain alterations on the existing regulations are necessary in the interests of the public, but, at the same time, will interfere with the private rights of property—ought certainly to have the power to acquire those rights, or to compensate, at the public cost, for the damage sustained. Railway companies acquire by Act of Parliament the power to compel proprietors to sell their property, and the most that can be said of their operations is that they are in the interests of public prosperity; and surely in the interests of public health—moral and physical—similar powers should be obtained by the civic authorities. But where is the money to pay the compensation to come from? you will probably inquire, the comparison will hardly hold good; the railway companies, while they expend the money, expect to realise dividends from their outlay, but there is no return here. That is so far true, as there is no return, at least in "hard cash;" but there would certainly be a large return in the improved condition of the people. The great sewage scheme in contemplation will not, so far as I understand it, give any return for the millions to be expended, other than the improvement of public health, and indeed there are sanitarians who hold that that scheme will simply be expenditure of an enormous sum to carry away and throw into the sea, material which, if dealt with in a different manner, might be made to repay the outlay in some measure.

I will not say another word on this subject, as it is hardly within our province. Tons of paper have already been used in discussing it, and it is not unlikely that tons more will be used in the same way before it is an accomplished fact. I merely refer to it as an illustration of money to be expended for the public good without interest expected, and that I might have the opportunity of saying that a mere tithe of the proposed cost would go a long way in compensating proprietors for placing restrictions on the number and kind of buildings to be erected on their ground. I do not propose to describe in detail the proposals of this provisional order; but perhaps I may be allowed, for the benefit of those, if there be any, who are not acquainted with them, to refer to them briefly and very generally. One of the main objects of the proposed order was to reduce the density of the population and to lessen the number of inhabitants per acre, and this desirable end was sought to be obtained by greater width between buildings, and by increasing the cubical space internally in small houses. As regards the space between buildings, the Act of 1866 provided that "it shall not be lawful for any person to let or use any apartment as a bedroom unless at least one-third of its height is above the level of the street or court, and unless there be in front of at least one-third of every window in such apartment a free space equal to at least three-fourths of the height of the wall in which it is placed, the height to be measured from the floor of the apartment to the wall head." Under this clause it was possible to have buildings four stories high—equal to, say 40 feet—placed within 30 feet of each other. Now, it appears that this was not the intention of the clause. The framers intended that the free space should be exclusively belonging to and connected with the building in which the apartment was placed. The new clause makes this clear; and, under it, buildings 40 feet high could not be closer than 60 feet from wall to wall. In regard to the internal space, the new clauses stipulated for houses of one apartment containing 1,200 cubic feet of space, instead of 900, as formerly provided for. Houses of two apartments were to have 2,000 cubic feet of space, instead of 1,500; and for three apartments not less than 2,800 feet, instead of 2,000. Then, as to the amount of air-space for each person occupying any apartment, it was proposed to increase it from 150 to 200 feet in the case of children under eight years of age, and from 300 to 400 feet in the case of persons over that age. An entirely new stipulation was introduced, fixing that the height of ceiling of any apartment used as a dwelling-house should not be less than 10 feet. There were many minor clauses, all, as I think, like those already named, changes in the right direction. Those provided for increased width of closes or entries to staircases. Another new and most important stipulation provided that all drains, soil-pipes, and cesspools should be constructed and ventilated to the satisfaction of the Master of Works, and that such drains should consist of glazed stoneware pipes, properly joined, &c., and connected with the sewer in a proper manner; and that such drains as pass under a building must be laid on concrete or other firm basis. All these drains were to be of sufficient size, and ventilated. Further, it was provided that, "in excavating for all buildings to contain dwelling-houses, the surface soil shall be removed to the depth of the foundations; where the surface soil is artificial, from the filling up of old quarries or otherwise, then the whole surface underneath and within the area of the walls shall be covered with a layer of concrete or other approved composition not less than 6 inches thick." As regards the regulations which struck at the continuance of building blocks of properties in the form known as "hollow squares," and which, as I have mentioned, may be said to be the rock on which the order was wrecked, I am of opinion that, apart from the question of "confiscation," they were, like the others, in the right and proper direction; while I do not agree with Dr. Russell that hollow squares are necessarily "boxes of stagnant air"—as they are at least boxes without lids, and there are openings in the sides in the form of closes or entries, through which currents of air must pass and cause a circulation in the box —yet I hold very strongly that they are most objectionable features in the laying out dwelling-house property.

I do not intend to discuss all the arguments for and against the provisions of the proposed order. It would be difficult to prove that

60 feet between houses four storeys high would ensure ventilation and sunlight, and that 58 feet would not do so; or that a ceiling 10 feet high would make a perfectly healthy room to live in, and that a 9-feet 6-inch ceiling would have a contrary effect. But in a large town regulations of some kind are essential, and a *minimum* must be fixed. Such things cannot or should not be left to the caprice of individuals. Regulations as to the laying of drains and their ventilation, and as to the public inspection of these arrangements are, without doubt, urgently required. It is true that, with the improved forms of cesspools and traps which the advance of sanitary science has placed at our disposal, every responsible architect and skilled builder will, as a matter of course, see that such things are properly attended to; but, unfortunately, there are buildings erected—and most of them of the kind we are dealing with—with which architects have nothing to do. They are erected by ignorant or unscrupulous building speculators, who are their own architects. Acres have been covered during the last few years with buildings of this class, and it is to be regretted that no law existed to allow a proper control being exercised over them, especially in regard to drainage. I could easily, if it were necessary, multiply instances within my own knowledge of buildings which could hardly be said to be drained at all. Some kind of drain pipes were perhaps there; but, so far from being laid and jointed in a proper manner, they might be said to have been merely thrown into their place, at all sorts of levels, without, in many cases, any attempt whatever having been made at jointing. Conscientious skilled men do not require regulations to enforce duty; but the authorities, nevertheless, must be in a position to counteract the culpable ignorance or cupidity displayed in the erection of the class of houses referred to. A considerable portion of the west end of Glasgow has been built on "made-up" or forced ground—old quarries, filled with *débris* of all kinds. The character of this *débris* may not be so black as it was painted by an eminent sanitarian in his evidence before Sheriff Clark, but it is certainly not selected very carefully, and in many instances cannot possibly form a suitable foundation—even after it is consolidated—on which to erect dwelling-houses. I therefore sympathise very strongly with the regulation which stipulated for such sites being covered with a layer of concrete. In the course of the investigation, evidence was given against the Dean of Guild Court being the proper tribunal for carrying out building regula-

tions; and again, it was pointed out that, even if such regulations were good, they could only be enforced inside the municipal boundaries, and that immediately outside this imaginary line—which I believe in some cases cuts right through the centre of a tenement—these regulations could and would be set at defiance. The position of the Dean of Guild Court, and its fitness for the work it has to do, was most ably discussed in a paper read here last year by one of our members, and I shall not venture to touch that subject. As to the other question, the remedy would be a general Building Act, or that the smaller burghs should—for the purpose in view at least—join themselves to the city.

I have, at much greater length than I had intended, alluded to this provisional order. My object was merely to call your attention to the direction in which the authorities think the existing building regulations require to be improved, believing that, although they failed to obtain the powers asked for in 1879, they cannot allow things to remain as they are at present, and that very soon some new order—or, perhaps, an entirely new Police Act—will be promoted; and as the portions relating to buildings interest us probably more than any other Society, the various questions involved might very well be discussed here.

There is another aspect of this great question—the improvement of dwellings for the working classes—which is not directly touched by the building regulations, as indeed it can hardly be. I allude to the crowding into houses of one or two apartments of persons of opposite sexes. The new regulations provide for sufficient, but certainly not more than enough, of air-space for each individual, but behind that there is the at least equally-important question referred to. I recently read an admirable paper by our respected fellow-townsman, Mr. James Salmon, on the dwellings of the industrial classes. Mr. Salmon states, I have no doubt on good authority, that out of seven million dwellings in the kingdom nearly six millions are occupied by the industrial classes. I find a similar proportion of working-class houses in Glasgow—the number of houses consisting of not more than three apartments being 89 per cent. Thirty per cent. of the whole of the houses are of one apartment only, and of these there must be a large number which are utterly unfit for human habitation—hovels, in which human beings herd rather than live, hotbeds of disease, the birth-places of all kinds of moral and physical evil. Something has been done by the operation of the "City Improvement Act" and the railway companies to root out this, the very lowest type of dwelling; but much remains to be done, and it is to be hoped that in any new enactment power will be taken to stamp them out effectually at any cost. Mr. Salmon put his plea for the necessity of this important subject receiving attention so admirably that I cannot do better than quote a few sentences :—

"It requires, indeed, but little evidence beyond what each of us can gather at our own fireside to know what a lasting influence for good a pleasant and well-regulated home imparts to human life and character, and with little trouble and no great circuit of inspection we may, on the other hand, gather abundant evidence of the influence for evil which the baneful class of houses just alluded to exercise over their occupants. In such houses the parents are face to face with insurmountable difficulties. How can they train their families as they grow up from childhood to manhood and womanhood, each requiring their own treatment, liberty, and accommodation—necessities which with them in their miserable abodes are unattainable?"

No body of men can more justly appreciate the causes of these evils than our architects, and none can so well point out the means by which they may be rectified. Dr. Russell, in his lecture on "The House," one of the Glasgow Health Lectures delivered during last winter, says :—"It is almost too horrible to express in naked, uncompromising language the jostling of birth and death, and the functions of life, which must be the daily experience in these small houses." Can anything be done to provide the working classes with sufficient accommodation to meet the wants of common decency at the rent which they can afford to pay? This is a most interesting question, and one which I do not think has commanded the attention it deserves in our city. In London and other large towns a great deal has been done in this direction. The building regulations do not touch the arrangement or plan of workmen's dwellings ; that, I presume, would be quite outside their province. They assume that the well-known Glasgow type will be perpetuated, and seek only to enlarge the scale on which it is to be built. It is, under the most favourable circumstances, in my opinion, open to many objections. The internal stair is bad, or may be so if not kept scrupulously clean. At least one cf the houses on each flat will not be a "through-and-through" house, and may therefore be defective in ventilation; for I believe that for a thorough and complete renewal of the air there is no system of artificial ventilation so completely effective as that which is to be obtained by an open window in the front and back wall of a house. The kind of building which, in my opinion, would be much more likely to be cheap and healthy, and which is not uncommon elsewhere, would be constructed on what is known as the "gangway" system or plan. It may generally be described as a building say 35 feet wide and perhaps four storeys in height. Gangways would be carried along the whole length of the building at each floor level. At proper intervals open staircases, constructed, like the gangways, of iron, would be erected outside the line of the gangway, and at the staircases—probably entered off the half landing—could be arranged water or dry closets for the two sexes. These closets would be lighted and aired direct from the outside. Each house would have a door to itself, entered from the open gangway, and in every case the house would be a "through-and-through" one. There would be no dark corners—and darkness means dirt—either in the staircase or the gangways or passages, the free air and the rains of heaven would play about them and wash and purify the surface.

The idea thus crudely sketched is a very simple one. If the building were of brick, which I propose it should be, I believe—although I have not gone into the calculation in any detail—that a much larger cubic space could be given, say for a £10 rent, than can possibly be afforded in the stone building arranged on the common plan. There is a prejudice against the use of brick in Glasgow, but I think it is a most suitable material for the purpose we have in hand. The walls might be built hollow to ensure dryness, and provide a space which could be utilized for ventilation; and if the bricks were selected, or a specially smooth-faced kind of brick made for use on the internal face of the wall, probably plaster might be dispensed with altogether, and the surface of the brick limewashed. This would not only be an economy to begin with, but would save cost for upkeep and abolish a most convenient harbour for dirt and vermin. Other directions in which economies might be practised will no doubt occur to most of you. I think something might be worked out of the suggestion, and if private enterprise does nothing, an experimental block might be erected by a philanthropic Town Council, or at least ground might be given on such terms as would encourage private individuals or a company to test the problem on something like the lines indicated. With a view to provide as many separate rooms as possible to each house the standard size for each room would require to be reduced below that indicated in the provisional order. I would *not* reduce the cubic contents per *person*. With one large kitchen or living room, the bedrooms might be small. No more persons would be put into the space; but the subdivision would be greater, and thus secure more privacy and separation for the sexes. The blocks of building should be at least as wide apart as the provisional order required, and there should be no cross ends. The "hollow square" would not be repeated, and the houses would be as free and open at the back as at the front. A private lane, used only for cleansing purposes, would be carried through between each pair of blocks. From these the courts could be cleansed and flushed with water in dry weather, and the ash-bin emptied every morning. I have used the word "ash-bin" instead of "ashpit," for I propose to abolish the latter contrivance. Instead of the brick or stone erection large enough to contain the house-refuse of a whole tenement accumulated during a month or more, I would substitute an iron bin *so small as to compel daily removal* of the refuse.

The disposal of the refuse from ashpits is another question of great importance. In connection with this subject, I have lately seen a report to the Sanitary Committee of the Commissioners on Sewers of the City of London, "On some of the methods of disposing of all kinds of refuse by cremation." The report is prepared by the Medical Officer of Health for London—Dr. Sedgwick Saunders—and it proceeds, with great detail, to describe the "cremator" or "destructor" as it is called, and the work done by it in various important boroughs in England. One effect of the destructor is, besides destroying its injurious properties, to reduce the material to about one-sixth of its original bulk—a very important matter, indeed, where carriage has to be considered. Regarding one of the stations visited, where the system is in practice, the reporter tells us that it is situated in the midst of a dense population, surrounded by houses of a respectable character, and deals with the refuse of sixty thousand persons. At the time of the visit the place was entirely free from smell, and, although night-soil in large quantities was mixed with house-refuse, the carbonaceous matter in the cinders had completely deodorised them. The products of the refuse, after passing through the destructor, seemed to have considerable value. At some of the places visited by the deputation it was observed that a new commercial product of marketable value had been created by the use of the destructor—namely, clinkers—resulting from the process of burning the refuse. These are ground by heavy rolling mills into powder, and then mixed with 25 per cent. of lime and a suitable proportion of water, and the result is a useful mortar or cement, found to be very tenacious and hard, from the oxide of iron and siliceous matter derived from the clinkers. Small, hard bricks are also made from the same material. I am not aware if the attention of our own authorities has been directed to this method of disposing of refuse, but it appears to me worthy of their consideration, and might be tried on a small scale, either by the town itself or, better still, by one or other of the small burghs in the neighbourhood. The practice, which was at one time common enough in Glasgow, and already referred to—that of using the ashpit refuse for filling up old quarry holes—is still carried on in some of the fashionable suburbs. Shifting the refuse from the ashpits behind the terraces and spreading it out in front of them is not removing the nuisance. I believe that the turning over of the material in its removal has the effect of reducing its disease-producing properties; but it is at least unsightly. By-and-by the mass will consolidate, a light coat of grass will be sown on its surface, and the public will be informed that there is eligible building ground to feu; stately terraces will be erected, and occupied by people who, if they ever knew, will probably forget that they are living on the top of a "free coup."

Having thus very generally, and yet, I fear, with some patience-taxing detail, alluded to various matters which, besides being of pressing public importance, are of special interest to us as a Society, I will now refer to a subject to which you have already given some consideration, but which, from its importance, may well receive your further attention.

During last session Mr. Robert Scott read an able and exhaustive paper on "Measurers, their position and practice." The subject created much interest, and a good deal of discussion ensued.

Nothing is so important in connection with every building contract as the proper and accurate preparation of the schedules or bills of quantities and the arrangement of the conditions of the contract in such terms as will ensure fairness for both sides, and I am glad to see that the suggestion with which Mr. Scott closed his paper—viz., "that a Measurers' Institute or Association should be formed"—has been adopted, and that that body is, or will be very shortly, in active working order. It will have plenty of work to do, and from the well-known energy and talents of the gentlemen who are taking the lead in the matter, I think we may look for new rules which will effect a great improvement, or at least greater uniformity in the mode of measurement. Mr. Scott tells us, in regard to the mode of measurement, that a statement made in a paper read before the Architectural Society 19 years ago may be reiterated to-day with even greater truth, namely—"It is commonly remarked that a contractor must know the measurer before he can know the mode of measurement." If this is true, which I do not doubt, it is a very unsatisfactory condition of things, and the sooner it is put an end to the better. It appears that, although there is the familiar expression "Glasgow mode of measurement," there is really no formulated rules and regulations for the measurement of any class of work, except mason work. I have no doubt it will be part of the work of this new Society to assist in the preparation of rules and regulations for all branches of work, along with the representatives of the trades concerned, and, of course, the Institute of Architects.

I may mention, in this connection, what is probably known to most of you, that the latter body have already had submitted to them by the Masons' Association new rules and regulations for the measurement of mason work in Glasgow, and that they are giving them their fullest consideration.

There is evidently ample subject for discussion awaiting the various parties in the building trade, and while it would be impossible to fully consider the multifarious details connected with the maturing of even one branch of the subject in the limits of an ordinary meeting of a section, I give it as a suggestion to any of our members that one or two evenings of the session could be devoted with great advantage to the consideration of such matters. It is not within the scope of my remarks this evening to consider questions as to the modes of describing work which will be most readily understood, and *understood* in *one* way only, by contractors; but it appears to me that if such expressions as "extra over," "additional over," and allowances generally could be eliminated from all schedules something would be gained in the direction of simplicity. No mode of measuring any kind of work can be entirely satisfactory which does not describe and classify exactly what is intended to be executed. All arbitrary allowances should be given up. If I understand Mr. Scott aright, this is his view also, and I know it to be the opinion of a large number of my professional brethren.

There are one or two other matters which occur to me, relating, however, more particularly to the conditions of contracts, which it might be well to consider at the same time. One of these, and perhaps the most important, refers to the time and manner in which payments should be made to contractors; and closely allied to that question—indeed, inseparably connected with it—there is the arrangement for the time at which after-measurements should be made. The former matter is, however, often, although not always, arranged beforehand; but I think I am right in saying that it is very seldom that any bargain is made as to the time at which the measurement should be done. And yet it seems to me that the one thing hangs upon the other, and that payments should only be made on the certificate being produced from the measurer that the work is done. It would then be the duty of the architect to satisfy himself that it was *properly* done before certifying for payment. His business is to deal with quality, not quantity. In this way a guarantee would be afforded to the contractor that he would be paid for his work within a reasonable time after its execution. Responsibilities which they have no right to bear would be removed from the shoulders of the architects as to possible over-payments, and all parties would be satisfied that the work being paid for had really been executed. I think some such clause as this essential to provide against the possible abuse of the after-measurement system—the system which is usually followed in Glasgow. I see no reason to suggest the abandonment of that system in favour of the "slump sum," as I believe it to be as free from objection as the latter, and probably the fairest for all parties. But it is stated that there have been cases where the house was completed and occupied before a tape had been put upon it. In such circumstances it is simply impossible that the after-measurement can be a fair representation of the work. If there is room for such things occurring from any cause under the present system, it certainly ought to be provided against. I see no difficulty in arranging for the work being measured at certain stages in its progress, and paid for within a reasonable percentage at a fixed time after the measurement or certificate that the work has been done is presented to the architect.

There is a further and not unimportant advantage in this plan. The proprietors would be in possession of accurate information, at every stage of the work, as to the amount being expended, and, again, the measurement having been made and the work paid for in what I may call easy stages, the final measurement would not be the formidable document we often find it. Then, questions arising as to extra work could easily be settled at the time when the work could be seen, and not as now—it may be a year or even more after it is done and covered up, or not conveniently accessible.

I think that payment for work on measurement only is a most important point. Generally, though not always, the architect has to make, in what must be to some extent, a haphazard way, a calculation of the amount due to the contractor, and as he may be held responsible for over-payment made on a certificate, he naturally desires to keep himself safe by working with a large margin. It is seldom satisfactory to himself, and still more seldom satisfactory to the contractor. But, while I am of opinion that the work should be measured up and paid for at frequent intervals during its progress, I do not think that the work should be taken off the contractor's hands piecemeal. The proprietor bargains for a completed building, not for a bit of walling or a tier of joists.

This suggests another point—small in itself, but still one which occasionally gives rise to some difficulty. I allude to the employment and payment of a watchman during the progress of the work. The present custom is for the proprietor to do so, but, as I hold that until a building is completed it is not his property, he has no right to watch it. And I say this in spite of the law or custom by which a contractor failing to fulfil his contract cannot remove his plant or material—built or unbuilt—from the ground. The proprietor merely retains what is on his ground in forfeit for the non-fulfilment of the contract, or in security for the payments which he has made to account. Indeed, the principle that I am contending for may be said to be already admitted under the clause which stipulates that the contractor is bound to make good all damage to the work in its progress, and deliver it over in a perfect condition, and this too irrespective of whether it is watched at his expense or not.

There is another small matter in connection with masons' contracts which I may refer to—viz., the payment of water, which it has been the custom to exact from the proprietor. I understand there is no ground for this charge among the existing rules and regulations for the measurement of mason work, and I can imagine no good reason for making a separate charge for water. It is part of the material from which mortar is made, and it seems to me that it would be quite as reasonable to charge separately for the sand and lime. No doubt it has to be paid for by the contractor, and he must recoup himself; but its cost ought to be included in the general price for building. There are many other points connected with the payment for jobbing which might well be considered. Proper arrangements should be made beforehand for checking both the quantities and the rates for such work, if it has to be done. Another important matter, which ought to be settled now, is the appointment of an arbiter or referee in the case of disputes under building contract. The usual clause, which appoints the architect the sole judge, with the power of giving a decision which will be final and binding on both parties, has long been held by contractors to be objectionable. The architect, from their point of view, is the proprietor, and to make one of the parties to a bargain the arbiter in any dispute arising from the bargain can hardly be considered equitable.

It is creditable to all concerned, considering the enormous number of building transactions in a city like this, that so few cases of dispute arise, and it is likely that, under the improved state of things which we may expect under new rules and regulations for the measurement of all kinds of work, the proportion will be still smaller; but, nevertheless, an arbiter other than the architect ought to be appointed under every building contract.

I might easily occupy your time further on this question of measurements and contracts, but I hope there will be other opportunities, when all sides can be heard, and I will not detain you further on this occasion.

I wish, before leaving the subject, however, to refer to one other matter—the payment of measurers' fees. These are at present paid one-half by the proprietor and one-half by the contractor. Of course the contractor has to allow for this payment in his prices, and thus it is the proprietor who pays the whole in the end. I do not see why he should not pay the whole direct, and so relieve the contractor of all trouble in the matter. At all events, if the present custom is to continue, the amount of the fee should be clearly stated in the schedule, and that is not done at present. I understand that this question of fees is being or has been considered by the Measurers' Association, and if they will pardon the liberty I am taking, I would counsel them to avoid the percentage system. Let them, by all means, if they see their way as to fix a minimum, but I think the system, which is followed in my own profession, of fixing a maximum, which any one, no matter what his experience may be, can charge and enforce the payment of, is objectionable. There is ample evidence that in our profession it is causing dissatisfaction all over the country. A recent writer on the subject said—"For five per cent. you can get the advice of the last fledged pupil who has put a brass plate on his door, and has begun to gain experience at his client's cost, of the pushing individual who calls himself auctioneer, surveyor, architect, and estate agent all in one, or the accomplished artist, perfected by years of experience and a lifetime of study. In modern architectural practice, as in death, all men are equal. The painter, as his work improves, raises his prices. The barrister expects a higher fee as his name becomes known," and the same may be said of the medical man. "But the only reward, with rare exceptions, that comes to the most successful architect is to get at least twice or even ten times as much work as he can personally manage, all paid for at the same rate which he received at the outset of his career." All this is perfectly true, and is, to some extent at least, brought about by the fixed maximum rate. In my own profession and in that of the measurer the payment ought certainly to bear some relation to the character of the work required, and a very different fee ought to be charged by both, for the work required in connection with a factory or workshop and a church, mansion, or public building.

I hope that much good will result from the consideration of regulations for measurement and other matters connected therewith. If it should enable us to present a more reliable estimate of cost to our clients, that would be something gained. In his opening address, a late president of the Royal Institute of British Architects, remarked, that there was a certain want of entire confidence in architects amongst the public, arising, as he thought, from, among other things, a want of credence in the accuracy of architect's estimates, and there can be no doubt it is in every one's experience that such a feeling exists. I do not stop to consider why it should be so, but I will say that the architect is not by any means always to blame. The fault may, and very often does, lie with the client himself, or it may be careless measurement from the plans, or after-measurement from the executed work, or from trumped-up bills of extras and jobbing accounts which cannot always be checked. It is enough for us to know that the feeling does exist, and that there is occasionally good grounds for it—to see the importance of doing whatever will raise our position and inspire confidence in the minds of the public. Apart from this matter, I think it will be admitted that the public, on the whole, appreciate our work. Glasgow architecture, both in design and execution, is not second to that of any other city where similar opportunities are afforded. Our late President gave us a most interesting historical account of Glasgow architecture of the past—the work of such men as Adams, Hamilton, and Stark, of Wilson, Rochead, and Thomson—and I think it not unlikely that a future historian will be able to speak not less admiringly of the work of the immediate past and future. It is true that in the course of a recent leader in one of our daily papers, advocating the erection of new galleries for the exhibition of works of art, the writer said:—"For the required purpose a costly building, with a fine architectural elevation, got by competitive plans, is not needed. Indeed, our experience of architects and competitive plans is not encouraging. Instead of an architect, a civil engineer, accustomed to work in stone and iron, would serve the purpose better, and would be infinitely cheaper."

Some of us may sympathise with the remarks as to "experience of competitive plans," but I do not believe that public opinion was fairly represented, as it usually is by that journal, when it said that their experience of architects had been unsatisfactory. And, as to the opinion expressed that it "would be infinitely cheaper" to employ an engineer—by which is meant, I presume, that he would design a cheaper building—no facts are given in support of the opinion, and I cannot imagine that any can be advanced. Indeed, I think that the contrary is more likely to be the case. If one may judge from their work, engineers seem to be less hampered by consideration of economy than architects are. But, apart from this, I do not think that, for the purpose named, the Glasgow public would be satisfied with the description of building hinted at. Something more than a building like a workshop or a railway shed would, I believe, be desired by the citizens of Glasgow to contain their art treasures.

This leads me to refer for a moment to the work of the architect and the engineer. It appears to me that while railways, bridges, dry docks, and breakwaters should be left to the engineer, and houses, churches, and public buildings to the architect, yet I am of opinion that in important works, where there are great strains or loads to consider, the architect may well call in the aid of the engineer; and, on the other hand, there is room for improvement in the design of railway stations, girder bridges, and such like structures, and that it would be a public advantage if the architect were permitted to advise in such matters. This is all the more necessary in Glasgow, as it is very likely indeed that our streets will, within the next few years, be still further cut up with new railways. There seems no reason why a railway bridge crossing a leading thoroughfare should offend good taste by its naked severity, although that were preferable, in its simplicity, to the same form dotted over with trivial and unsuitable ornament, as we often see it. If the learned skill of the engineer and the educated taste of the architect were combined, such structures, instead of being an eye-sore, might be made to lend interest and variety to the dull monotony of our streets. As I have already said, I do not believe for a moment that this newspaper opinion reflected to any extent public opinion, yet we cannot shut our eyes to the fact that there is sometimes an inclination shown on the part of people whom we would expect to know better to employ other than architects to do architects' work.

At the outset of my remarks I mentioned that this section was the direct descendant of the Architectural Society. I propose to conclude by reading an extract from an opening address by the then President, the late Alex. Thomson. It seems to me to be as applicable to the state of things now as I have no doubt it was then—in 1861.

"It may be desirable that I should briefly allude to what may be considered the mission of the Society. Its object is not merely technical. We do not wish to wrap our art in mystery in order to gain an ascendancy over a superstitious public. On the contrary, I believe that it is the experience of every competent practitioner that the more his client knows of architecture the less he will interfere with the carrying out of his views. It is most desirable that all connected with building—the representatives of the various trades, the measurer, the architect, the client, and the general public—should meet on the same platform; that each should understand the relation which he bears, and the duties he owes to those around him, and to the whole; and by their united efforts to raise architecture to that position which it has occupied in the best periods of the world's history. The tradesman ought not to be content with merely fulfilling his contract so as to secure his price—he should find his chief pleasure in his calling, giving it the best attention that any worldly pursuit deserves. Let everything be done honestly and satisfactorily. Let him make himself acquainted with all scientific modes of construction, with the properties of the materials with which he has to deal. He should understand as much of architecture and architectural expression as enable him to bring out the spirit of any work put into his hands. The architect's education should embrace all these, and it is incumbent on him that he practice them with great care. But he has, besides, another class of duties to perform; and, first of all, he has to fill his heart with wisdom, and to exercise his mind with great thoughts, for the end and aim of his art is to express these. To aid him in so doing let him search the whole world of nature and art for modes of expression, not that he may quote them entire and unchanged, but that he may learn from them something of the nature and meaning of lines, of forms, of proportion, of light and shade, and of colour. Let his imagination be filled with images rather than his memory with modes. How often have we heard it said that architecture was a finished art—that every form of it had been wrought out. I have never allowed myself to think so, and it is gratifying to observe that, during the last few years, our illustrated periodicals bear evidence of the approach of an era of life and progress, and I hope to see the day when it will not be considered necessary to answer the question, 'What style do you call that?' but when every man will have his own style as in literature. To our clients I would say do not put yourselves above your advisers. The absurdity of such a course seems evident enough, one would think, and yet it is the one usually followed. Taste is supposed to be a thing inherent to every man who can afford to indulge in its practice; and yet the fact is that the greatest disparity exists towards the outer rim of the social wheel. As we approach the centre we find men agree as to general principles, and certain objects exist which all men of intelligence pronounce to be beautiful. Our taste changes with our experience, and the more we know the more pleasure do we derive from the study of art. I think no sensible man would be guilty of perpetuating in stone and lime the crude notions of the hour, when, by giving his architect a judicious latitude, he would be almost sure to get something that would afford him permanent pleasure."

XII.—*On a Changing Tesselated Structure in certain Liquids.*

By Professor James Thomson, LL.D., F.R.S.

[Abstract of Paper read to the Society, 15th February, 1882.]

In June, 1870, the author, when on an excursion of the Belfast Naturalists' Field Club, happened to notice in a tub of opaque-looking water, in the yard of a roadside inn, a structure showing itself which appeared remarkable, and excited a good deal of curiosity among members of the Club then present as to what might be its nature and mode of origin. The water, viewed from above, presented a tesselated appearance, considerably resembling such patterns as are exhibited by vertical basaltic columns when exposed to view in a horizontal section—such, for instance, as may be seen at the Giants' Causeway or at Staffa. On the water being disturbed the tesselated structure was destroyed, and eddying streams of pearly lustre showed themselves in its stead; but the same kind of tesselated structure as before speedily reappeared, and, on being watched for some time, it was found to be perpetually, though slowly, changing. Inquiries made as to how the water had been previously used did not elicit any definite information. A sample of the water was then brought away by the author for further examination. It presented, when shaken in a clear glass bottle, a remarkable satin-like, streaky appearance, with the pearly lustre before mentioned.

Like phenomena were afterwards noticed occasionally in soapy water, and so it became probable that the water originally noticed might have been soapy, and that soapyness had probably been associated with the production of the phenomena.

Various experiments and observations on soapy water have since been made, and results which seem worthy of notice have been arrived at. The more obvious features of the phenomena must of course have been seen thousands of times before by washerwomen

Proceedings of Philosophical Society of Glasgow, 1881-
Plate VI.

Fig. 1.

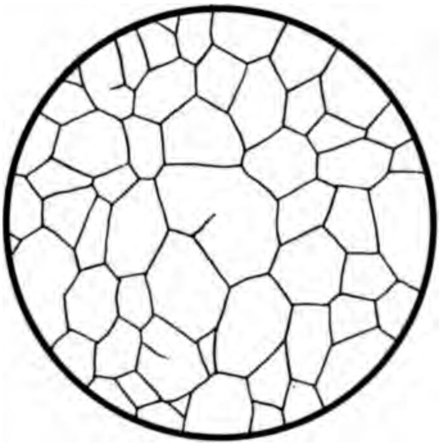


Fig. 2.

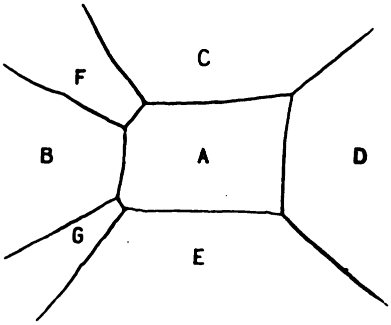


Fig. 3.

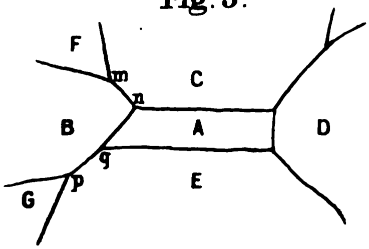
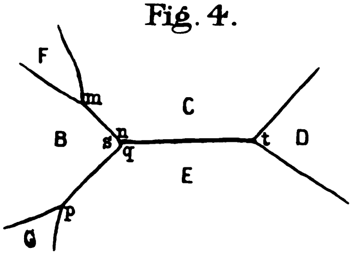


Fig. 4.



and others; but perhaps the conditions may have been left unheeded, and without receiving any scientific attention or scrutiny.

The occurrence of the phenomena seems to be associated essentially with cooling of the liquid at its surface where exposed to the air, when the main body of the liquid is at a temperature somewhat above that assumed by a thin superficial film. A very slight excess of temperature in the body of the fluid above that of the surrounding air is sufficient to institute the tesselated changing structure, provided that the soapy water is in other respects in good condition for taking the actions to which the phenomena are due.

An easy method of procedure for making suitable experiments and observations, and which was shown to the Philosophical Society in illustration of the communication, will now be explained. A glass pan was filled to a depth of four or five inches with soapy water of proper consistency, arrived at by previous trials. Then, to warm it slightly, one or two small tin cans of hot water were plunged into the soapy water, so that heat would be given to the soapy water by conduction through the sheet metal. The warm water cans were then removed, and the soapy water was stirred to bring the whole to about a uniform temperature. Then the pan and its contents were left undisturbed, and the subsequent behaviour of the liquid was watched. Swirling flows, conspicuous by their pearly streaks, showed themselves for some time, but with gradually abating speed, and in the course of five or ten minutes the eddying motions, accompanied by spirally-formed moving streaks, were gradually dying out, and the moving patterns on the surface were, by slow degrees, assuming a tesselated character. After the cessation of all such swirling motions, and disappearance of spirally-moving streams, the tesselated configuration might be found to continue, perpetually changing in all its individual details from minute to minute, but retaining the same general character for many hours together.

Fig. 1 in Plate VI. represents the general appearance that the surface of the soapy water in the pan would usually exhibit when left standing in the manner described. By continuous watching, it may be noticed that the smaller enclosed patches are generally diminishing in size, being encroached on by the larger ones until they collapse and cease to exist. At the same time the large ones show tendencies to sever themselves into two or more new ones, which in their turn either increase and split again, or diminish and go out of existence. To describe the numerous and varied features of transition in words would not be easy, but Figures 2, 3, and 4 show three successive conditions which have been observed as occurring.

In Fig. 2 in Plate VI. the patch A has larger neighbours—B, C, D, and E—contiguous with it, and it has also two narrow patches —F and G—contiguous with small portions of its boundary. The patch A is comparatively narrow in the direction between C and E, and is rapidly encroached on by those two large patches C and E, and becomes narrower than before, without necessarily being shortened in length. Also, during the same time, the narrow patches F and G collapse, each at its place of meeting with the boundary of A; and in each case where the collapse takes place a bounding line is left between the two, which come together, as is shown by *m n* and *p q* in Fig. 3, the patches F and G of Fig. 2 having retired to their new positions, shown as F and G in Fig. 3. A little later, and the patch A is observed to have disappeared entirely, by collapsing into the line *s t* in Fig. 4.

Multitudinous varieties of changes, partaking more or less of the general character of those here described, may be noticed in various watchings of the behaviour of the soapy liquid from time to time. The patches, with their boundaries, when viewed with favourably applied light, show appearances as if each patch were formed as the top of a column of slowly rising fluid, having a mother-of-pearl-like lustre, seemingly at a little distance below the surface of the liquid, and with a thin layer of more translucent liquid lying on the tops of these pearly patches. It seems to be that there is on the whole a very slow ascending motion in these columnar spaces, and that above, there is a thin superficial layer of cooler and seemingly more translucent liquid, receiving perpetually new supplies from the rising substance of those columns, and flowing outwards over each column top, and that the two sheets, spreading out on each of two contiguous columns, plunge downwards, where they meet in the mutual bounding line of the two spaces or column tops, and so form a descending current or septum between the two columnar spaces. Where three of the bounding lines meet at the junction of three column tops, the downward current seems to be more active than at the other parts of the septums. The various ascending flows here spoken of as columns, or columnar spaces, for want of any better nomenclature, may probably not exist like separate columns with septums between them of descending liquid except near the surface. It seems likely that the down-flowing liquid of the so-called septums may tend to gather into thicker streams descending from the corners of the surface patches where three of such spaces meet; but the internal motions, being concealed from view, remain as yet obscure, and in a great degree unknown.

Scrutiny of such motions as have here been briefly mentioned and speculated upon has been carefully made in many ways, but the one which gave the most remarkable indication was by sprinkling minute crumbs of dry aniline dye on the surface of the liquid, and observing the motions of the liquid, as indicated by long worm-like coloured lines, which, as it were, crept forward from the crumbs of the aniline, these crumbs themselves remaining stationary, or nearly so, on the surface of the liquid. The blue worms of aniline glided along the pearly tops of the columns, sometimes forming a pit or depression, down which they would plunge, accompanied by some of the cooler surface liquid; but often they continued their course, so as to reach a bounding septum, down which they could be seen to plunge rapidly. They gave very clear indication of there being a down-flow of the cooler surface liquid in every septum.

As to the physical and optical conditions to which the pearly appearance may be due, the author offered some suggestions, but stated that much must remain still to be found out by microscopical or other researches, which he inclined to recommend to any whose opportunities and inclinations might lead them to take interest in the prosecution of such researches. He thought it probable, judging from numerous appearances, that the soapy liquid might contain in suspension multitudinous flattened or elongated particles, like scales or crystals, or comminuted glass hairs, which, in the motions and distortions of the liquid, would tend to place their flat faces or their elongated sides in approximately-parallel directions, and so would give special optical effects by their reflexion of light. He offered any such suggestions, however, with great diffidence, wishing to leave the subject entirely open for better researches than any he had had opportunity to attempt.

A like tesselated formation, but without the pearly lustre, is often to be noticed in a plate or bowl of beef-tea or other clear soup containing minute flocculent particles in suspension and left cooling. The flocculent particles are capable of showing the tesselated structure, and of indicating clearly the existence of motions such as those described as operative in the formation of the tesselated structure in soapy water, but such particles are not capable of reflecting the light so as to produce the pearly lustre.

The motions now described and explained as occurring in the soapy water and other liquids when showing the tesselated structure he thus believes constitute one special case of what is often called convective circulation. He points out, however, that this case, with a thin film cooled at the surface while the great body of the liquid is at a somewhat higher temperature, presents essential distinctions from the case in which convective circulation is caused by heat applied at the bottom of the vessel. The surface phenomena and the actual motions throughout the body of the liquid are very different in the two cases, as may easily be seen by a little consideration, both theoretical and observational.

Professor THOMSON followed up the communication described in the above abstract, by giving to the Society an account of views which, a good many years ago, had been developed, partly by his brother Sir William Thomson, and partly by himself, on a somewhat kindred subject—Calm Lines on a Rippled Sea. Those new views he had submitted to the Belfast Natural History and Philosophical Society in a paper read on 7th May, 1862, of which an abstract is to be found in the Philosophical Magazine for September, 1862. (Fourth Series, vol. 24, page 247.)

The phenomena in the two cases—those of the Tesselated Changing Structure, and of the Calm Lines in a Rippled Sea, present certain features of close resemblance, and other features of wide distinction; and to facilitate the consideration of the two subjects together, an abstract of the paper on the Calm Lines is here subjoined. It is nearly in the same terms as that previously published in the Philosophical Magazine :—

On the Cause of the Calm Lines often seen on a Rippled Sea.

By Professor JAMES THOMSON, LL.D., F.R.S.

In this paper the object of the author was to offer an explanation of the origin of lines of glassy, calm water, usually long and sinuous, which are often to be seen extending over the surface of a sea darkened elsewhere by a ripple. He adverted to the commonly received supposition that these lines are due to some kind of oily film on the surface of the water, and to the prevalent idea that the oil is somehow given off from shoals of fishes. These suppositions, he thought, although having some slight foundation in the facts of the case, did not form the true explanation of the phenomenon. His brother, Professor William Thomson, had observed, and, in the autumn of 1861, had pointed out to him, that the water at the calm lines always contains considerable quantities of small floating objects, such as little detached pieces of sea-weed, leaves of trees, or the like; and had accounted for the smoothness of the water by the friction induced among the little undulations by the presence of those solid objects. The question still remained, however, as to what might be the cause of the leaves and sea-weed being arranged in such long and sinuous lines. One of these calm lines was noticed in the autumn of 1861, in Brodick Bay by Professor William Thomson and the author; and, on rowing into it, they found leaves and sea-weed abundantly diffused through the water there, while the rippled water on both sides of it was comparatively free from such objects. The line of calm water evidently sprang from a point on the shore where a small river, the Springbank Burn, entered the sea, and there could be no doubt that the leaves were supplied by that river. Still the supposition which tended momentarily to present itself to the mind, that the river was flowing out over the sea as a current in a meandering course, and thus constituting the sinuous calm line, appeared immediately on consideration to be untenable. The calm band, indeed, was noticed sometimes narrowing with advance along its course out from the land; but, if it were a current of lighter fresh water swimming on the denser salt water, it ought to be expected rather to be rapidly spreading out as a widening sheet in advancing from the land. It occurred to the author that the water of the river would actually spread out as a broad sheet over the surface of the sea, and that in its outward lateral internal flow it would constantly be carrying with it the leaves with which it was originally charged, and all such small pieces of sea-weed as it might meet with in the sea water, and that these would accumulate in a marginal line of the region of dispersion, which might be determined by some slight flow of the surface of the adjacent sea-water meeting this outspreading fresher water, and causing a downward or sinking motion, however slight, of the two meeting currents. The author does not mean to attribute the calm lines in general to the spreading of a sheet of fresh water over the salt water of the sea, but he thinks the general explanation is readily developed from the observations and explanation in the foregoing particular case. He supposes in general that, in estuaries and channels of the sea, and in lakes and rivers, the water must often be affected by various causes, such as tides, breezes, currents, and circulation due to differences of temperature, so as to be made to rise occasionally at some places and to sink at others. Now, along the line of meeting and sinking of two opposing surface currents all floating objects carried by those currents will be collected together; and there they will act as dampers, or floating breakwaters, for the small ripple undulations. The slightest possible inequalities of the forces of the two opposing currents at different places along their line of meeting, will suffice to account for the great sinuosities which the calm lines often show. If there should happen to be any oily scum thinly diffused on the surface of the water, this will be brought together, along with sea-weeds, &c., from a wide area, to the line of meeting and descent of the two opposing surface currents; and to an oily film having been frequently noticed on the calm places, though really brought to them in the way now suggested, the author inclines to attribute the supposition that it is their cause; but he agrees that very possibly, too, an oily scum thus sometimes brought together may co-operate with the seaweed and other floating objects in resisting the propagation of the ripple.

It has often been noticed by marine zoologists that in drawing nets through the sea, near its surface, for collecting small marine animals, they usually found that these animals were present in vastly greater abundance in the calm lines than in the adjacent rippled sea; and it has been supposed that, as the bodies of many of these contain oil, this, on their dying, might be given off from their bodies, and might float on the surface, and might cause the smoothness there observed. It has also been noticed that shoals of herrings are much more abundantly met with under the calm lines than at other parts of the sea, and it has been supposed that oil somehow given off from their bodies might come to the surface over the places where they for any reason would congregate, and might produce calm patches there, or calm lines in case of their being congregated in lines. In reference to such suppositions the author points out that even if we waive the question of the probable sufficiency or insufficiency of the supposed supply of oil proceeding from the small marine animals or the shoals of herrings to still the surface ripple, yet under these attempted explanations there remains the important question unsolved:—Why should these animals be found to congregate in long sinuous lines, extending often continuously for miles over the surface of the sea? He thinks, however, that the true state of the case probably is that the small animals are brought together by the same currents which, according to the supposition he has offered, collect the seaweed, leaves, and other floating objects into lines, and that the animals, not wishing to descend with the meeting currents into deep water, remain near the surface, and that the herrings or other fishes congregate to the same lines, in order to feed on the smaller animals. Also, further, the author thinks it worthy of notice that sea-gulls may very often be seen flocking together in the air over the calm lines in preference to other places, and dipping down there to feed on the fishes or smaller animals, and on such of the floating objects as may be suitable for their food.

XIII.—*On a New Family of Rugose Corals, including the Genera Cyclophyllum, Aulophyllum, and on the Genus Clisiophyllum.*

By JAMES THOMSON, F.G.S., Corresponding Member of the Royal Society of Science of Liège, and Honorary Member of the Royal Ducal Society of Jena.

[Read before the Society on 1st March, 1882.]

IN the year 1860 I prepared a number of transverse sections of the fossil corals from the carboniferous rocks of Scotland. During the subsequent four years I accumulated a considerable number of both genera and species. Many of these I was enabled to name and classify by the aid of the admirable memoir of Milne-Edwards and Jules Haime, published in the Transactions of the Palæontographical Society, 1850-4. There was, however, a number that, neither from their exhaustive descriptions nor excellently-figured plates, was I able to identify.

Towards the end of 1866 I read a short communication before the Geological Society of Glasgow, entitled "Notes of a New Group of Corals," and stated that, from the examination of a number of sectioned specimens from Beith, Bathgate, and Brockley, near Lesmahagow, I felt persuaded that in the carboniferous rocks in those localities we not only had represented the genus *Clisiophyllum* of Dana,* but during my investigations I had discovered a group which differed widely from that genus, and seemed to be altogether new. A variety of this group M'Coy described in the Ann. and Mag. of Nat. History, second series, vol. iii., p. 3, 1849, as belonging to the genus *Clisiophyllum*.

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* Report United States Explor. Exped.—Zoophytes. By James Dana, Geologist of the Expedition, vol. iii., p. 360, pl. xxvi., and subsequently in the American Journal of Science, vol. i., second series. In order that I might possess the most reliable authority regarding this genus, I wrote inquiring of Prof. Dana, and he kindly sent me a copy of a reprint of his original paper, for which and other kindnesses I offer him my cordial thanks.

For another variety of the group, M. Edwards and J. Haime created the genus *Aulophyllum* for its reception ("British Fossil Corals," 1850). In consequence of the hostile spirit expressed in the discussion that followed, that communication was not published.

In the summer of 1867, when in London, I submitted a number of the varieties of the group to Dr. Duncan, then Secretary of the Geological Society. He not only corroborated my own opinion, but suggested the desirability of a conjoint paper. That paper was published in the *Quarterly Journal of the Geological Society*, November, 1867, entitled, "On *Cyclophyllum*, a new genus of the *Cyathophyllidæ*, with remarks on the genus *Aulophyllum*." In the discussion that followed the reading of this paper, Prof. Huxley, F.R.S., then President of the Geological Society, stated that not only were these corals new, but that in any systematic work on classification there would require to be created a new family for their reception.

Subsequently I submitted these specimens to Prof. Owen, F.R.S., Palæontologist in the British Museum, who, after carefully examining the varieties, repeated a similar opinion to that of Prof. Huxley.

Since then I have collected all the varieties my time would admit of, from the different localities where the carboniferous limestone is exposed throughout Scotland; and I am persuaded that the materials now accumulated warrant me in giving the results of my investigations. In doing so, I am complying with a request that has been frequently made during the last ten years by a number of my Palæontological friends, suggested by the fact that most of the authors that have described the generic affinities of this group differ widely in their conclusions regarding the structural characters of the type specimen (figured by the Rev. David Ure, "History of Rutherglen and East Kilbride," 1793), and from the fact that I possess a transverse and longitudinal section of the reverend author's original specimen. These sections I procured through my friend, the late Dr. David Page, F.G.S., who proposed that the Council of the Royal Society of Edinburgh should place in my hands the type specimen, with authority to have it sectioned, and to take transparent sections for the purpose of having reproduced a *facsimile* by my nature printing process, and thus place in the hands of palæontologists the only satisfactory means whereby they might be able to form a proper estimate of its structural characters. Pl. II., Figs. 1, 1A, and

1B, represents the external aspect, from a cast made before the specimen was cut. In thus recording my observations, I am well aware of the difficulties that present themselves in this and in allied groups, and am satisfied that what is required for their proper identification is an accurate knowledge of the type of each genus, which can only be acquired from the examination of a section of the original specimen, and from a large series of the sectioned specimens of its allied varieties. With such aids, we may become acquainted with, on examining, many closely-allied species in either of the genera, leading, by their near affinity, to a clear perception of their generic relations. It is almost needless to point out that in this way only is there any hope of obtaining an accurate knowledge of the essential characters of fossil corals. It is true we cannot overlook the external aspects. In well preserved specimens generic distinction is in many instances clearly indicated; but I am satisfied that we can only arrive at a satisfactory solution of both generic and specific distinction from a careful study of as many sectioned varieties as is possible. Before, however, I enter into a detailed description of the group, I will briefly refer to those authors who have more or less directed their attention to this group of fossil corals.

Fungites—Rev. David Ure. "Hist. of Rutherglen and East Kilbride," p. 327, plate 20, fig. 6. 1793.

Turbinolia fungites—Fleming. Brit. Anim., p. 510. 1828.

Turbinolia fungites—S. Woodward. Syn. Table of Brit. Org. Rem., p. 7. 1830.

Cyathophyllum fungites—Geinitz. Grund der Verst., p. 571. 1845-6.

Clisiophyllum prolapsum—M'Coy. Ann. and Mag. of Nat. Hist., second series, vol. iii., p. 3. 1849.

Aulophyllum prolapsum—M. Edwards and J. Haime. Brit. Foss. Corals, introd., p. 70. 1850.

Aulophyllum fungites—Edwards and Haime. Pal. Foss. des Terr. Palæoz., p. 413. 1851.

Clisiophyllum prolapsum—M'Coy. Brit. Palæoz. Foss., p. 95, pl. iii. c., fig. 5. 1851.

Cyclophyllum fungites—Duncan and Thomson. Quart. Journal Geological Society. Nov., 1867.

From the diversity in the definition by these different authors I felt the desirability of delaying the publication of my own observations until I had procured additional evidence, and had had additional sections prepared. Since then I have prepared upwards of eight hundred sections of the genus *Cyclophyllum*, six hundred sections of *Clisiophyllum*, and twenty sections of *Aulophyllum* from the carboniferous rocks of Scotland [the latter are comparatively rare]; and, from a careful examination of the evidence now accumulated, I find, in common with the other groups of coralline remains in the genera under consideration, there are forms which have close affinities to allied groups. Indeed, so gradual and so complete is this transition that it becomes difficult to decide where to draw the line of demarcation. In this, as in my former communications, I have selected pronounced forms as central types, and have selected a series of the varieties that diverge in both directions. In order that we may have a clearer conception of their relationship to the genera referred to in the above list, I will briefly refer to the structural character of each genus.

FUNGITES. Rev. D. Ure. As no representative of the family fungidæ has yet been discovered in the carboniferous system, I feel that it is unnecessary to do more than refer to the name given by the reverend author.

TURBINOLIA FUNGITES. Fleming. The genus *Turbinolia* was established by Lamarck for the reception of a group of *Aporosa* corals from the Eocene system, and as defined by M. Edwards and J. Haime (Int. to the Fossil Corals Pal. Society Trans., p. 98), yield the following structural characters :—

"Corallum simple, conical, straight, and presenting no trace of adherence. Calice circular; columella styliform; septa exsert. Those of the last cyclum bent towards the neighbouring ones, and united to them; costa lamellar, straight, entire, and very projecting, the intercostal grooves presenting a double series of small dimples resembling pores." The *Zoantharia Aporosa*, as defined by these authors (*loc. cit.*), contain groups whose septal system are multiples of six, and there are no tabulæ, characteristics which clearly preclude them from the sub-order *Zoantharia Rugosa*, the septal system in the latter being multiples of four, and the fact that the genus *Turbinolia*, as recorded by these authors, being restricted to the Eocene system, precludes me from admitting it as having the slightest affinity to the group under consideration, and may therefore be disposed of without further remarks.

CYATHOPHYLLUM FUNGITES. "Geinitz. Corallum simple or compound; no costa; septa well developed, extending to the centre of the calice, and twisted together so as to produce the appearance of a small columella; tabulæ occupying only the centre of the visceral chamber, the outer portion of which is filled up with numerous visceral dissepiments. A single wall situated exteriorly, and produced with a complete epitheca."

CLISIOPHYLLUM. Dana. (Original description.) "Quite simple, ramose or aggregato-glomerate; corallum having the cells radiate; texture internally at middle, consisting of septa and cellules converging upward, but without a distinct axis; texture exterior to this middle portion cellular."

CLISIOPHYLLUM. Dana. As defined by Edwards and Haime. "Corallum simple, turbinate; septa well developed, and rising towards the centre of the calice, so as to form a spurious columella, but not twisted."

AULOPHYLLUM. Edwards and Haime. "Corallum simple, septa well developed. A double mural investment, the interior wall dividing the visceral chamber into two portions—one central and columnar, the other exterior and annular; no columella; tabulæ but little developed."

CYCLOPHYLLUM. Duncan and Thomson. "The corallum is simple, tall, cornute, or more or less cylindrical; the wall is very thin, and is formed of epitheca; the calice is deep, and its margin sharp; there is a central projection at the bottom of the fossa, separated from the ends of the larger septa by a deep groove. This central mass consists of an endothecal covering, with numerous septa attached to it internally, and coalescing to form some large septa, which ramify over the central depression, which represents the top of the columella. The columella is essential, and is made up of laminæ, which arise from the base of the corallum and from the dissepiments which unite them. The endotheca is largely developed, and the septa are very numerous. There is a fossula with three small septa in it, and processes of the endotheca of the central mass projects into it."

From the above it will be apparent that these authors rest their generic definition upon structure totally at variance with each other. Without entering into the minuter details of each, I will briefly notice their more prominent characteristics.

In the *first* place, the genus *Cyathophyllum* was founded by Geinitz for the reception of a group of corals whose septa passed into the centre of the visceral chamber, the centre of the corallum being composed of more or less broad tabulæ. Recent investigations have shown that, in many of the species of *Cyatho-*

phyllum, the septa stop short of the centre, and the broad flat tabulæ are exposed, occupying the centre and forming the floor of the visceral chamber (Pl. IV., Figs. 10 and 10A).

Secondly, Clisiophyllum was established to include a group of corals in which a conical boss occupies the centre of the calice, which suggested the name clisia—κλισία, a tent—which in the transverse section is seen to be formed by the lamellæ which spring from the inner ends of the primary septa, and converging inwards and upwards to the centre of the calicular cavity. These again in a longitudinal section are seen to be united by a system of interlamellar convex cellular tissue, convexity pointing upwards and inwards, and converging to the centre of the central area, and forming a pseudo-median line which extends from the inferior to the superior extremity of the corallum.

Thirdly, Aulophyllum was established by M. Edwards and J Haime to include a group that possessed a double mural investment which divided the visceral chamber into two portions. The centre is tubular, and its centre is occupied with minute complete tabulæ, which extend across the centre of the visceral chamber transverse to the axis of the corallum.

Fourthly, Cyclophyllum, as defined by Duncan and Thomson, includes a group of corals that had a central area that projected at the bottom of the fossa and separated from the larger septa by a deep groove, and possesses an endothecal covering; and around its inner margin there is a system of septa which pass inwards and coalesce, and form a spongy tissue in the centre of the central area. This tissue springs from the base of the corallum, and is therefore essential.

These points of difference may be briefly summarised as follows:—*Cyathophyllum* may be readily distinguished by (1) the arrangement of the septa, which, in some forms, extend into the centre of the visceral chamber, while others stop short; (2) there are no lamellæ in the central area; (3) the tabulæ of the central area close in and form its floor, and usually occupy at least a third of the total diameter of the corallum, and in some instances they occupy a larger area (Pl. IV., Figs. 10 and 10A.) Structural characters so widely different warrant me in homologating the classification of Edwards and Haime, and relegating the group to the genus originally established by Gienitz for their reception. (4) *Clisiophyllum* is separated from *Cyathophyllum* by the possession of the conical boss that occupies the centre of the visceral chamber, and which is formed by a system of lamellæ, which converges inward from the inner margin of the primary septa to the centre of the central area, and which in a longitudinal section is seen to be united by a system of convex plates pointing upwards and inwards (Pl. VI., Figs. 1A, 2A, and 5A). (5) *Aulophyllum* is readily distinguished from *Clisiophyllum* by its double wall, the inner wall forming the periphery of the tubular columella and the minute tabulæ occupying its centre, and from the fact that in a longitudinal section, instead of a conical boss in the centre of the calicular cavity, it presents the form of a double cup (Pl. IV., Fig. 4). (6) *Cyclophyllum*, as defined by D. and T., is at once distinguished from *Clisiophyllum* by the presence of a double wall, which in a weathered specimen (Pl. II., Fig. 4) is seen to possess a central columellarian tube, and from *Aulophyllum* by the fact that the centre of the columellarian area in a longitudinal section is occupied by more or less discontinuous vertical lamellar plates, and united by minute interlamellar tissue. With these points of difference the two latter have one point in common—*i.e.*, that each present in a longitudinal section the aspect of a double cup (Pl. II., Fig. 2, and Pl. IV., Fig. 4), which suggested the family name which I now propose to establish. In the former the centre of the central area is occupied by minute tabulæ, while the latter is occupied by minute vesicular tissue.

FAMILY.

DIPLOCYATHOPHYLLIDÆ.* Fam. nov.

Corallum simple. Septa well developed, and extend inwards for about a third of the total diameter of the corallum. Septal fossula variable, columella tubular. The longitudinal section presents the form of a double cup at the superior extremity (Pl. II., Fig. 2).

The form and structure of this family are so distinct, and differ so widely from all the other groups of coralline remains that have hitherto been discovered in the carboniferous rocks, the double cup and septal system around the inner margin of the inner cup suggests that it is probable these septa are the expression of a double circlet of tentacles—an outer around the periphery of the corallum and an inner around the periphery of the columella.

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* This name was suggested by my old and much-valued friend, the late Dr. John Scouler.

becoming much prolonged. I have reconstructed a model of the aspect I conceive the polyp presented when in life—the upper portion representing the polyp's body, while the lower, or the portion below the circular line, represents the sclerodermic corallum (Pl. I.).

Genus Cyclophyllum, Duncan and Thomson.

Fig. .

Generic Characters.—Corallum simple, cylindro-conical, cornute, and curved. The cylindrical forms are frequently curved and twisted, while the cornute forms are shorter and never so tall. The epitheca is variable in stoutness. The calice is usually deep. Those forms with the deep calices are thin around the margin, while those varieties whose calices are not quite so deep are not so thin, and in some it is more or less everted, and exhibiting in the centre of its floor a cup-shaped projection, which is more or less raised above the inner margin of the primary septa (Fig. 1B), which in a transverse section is seen to be surrounded by a system of minute septa, which converge inwards, coalesce, and assume a more or less reticulate aspect in the centre of its floor (Fig. 1A). The septa are variable in number and stoutness, and are of two orders. The primary septa never extend into the wall of the cylindrical columella, but are united to the central mass by a system of sub-convolute plates, which fold round and form the wall of the columella (Pl. II., Fig. 4). The primary septa exhibit laminæ to near the periphery. Near their outer margins they are single and thin. The interlamellar spaces are occupied by minute transverse granular plates, in number from six to sixteen in the space of a line, which, in a longitudinal section, are seen to pass inwards and downwards along the inner face of the laminæ (Pl. II., fig. 5A-B). The secondary septa usually extend inwards for fully the half-length of the primary. They are united by interseptal dissepiments, which are few in number near the inner margins of the primary septa, and more or less numerous in the external area. The walls of the septa, the interseptal tissue, and the endothecal structure consist of two layers—the inner dense and granular, the outer also granular, but much less dense. The fossula is variable in size in the different varieties, but usually well marked.

The longitudinal section (Fig. 1B) is triareal. The central area is tubular, and composed of thin discontinuous vertical columellarian laminæ, and each of these laminæ is united by concave tabulæ, while the outer margin is composed of convex cellular tissue, convexity pointing outwards and upwards, and forming the wall of the tubular columella. The intermediate ("interlocular") area is occupied by convex tabulæ, convexity upwards, and unite the inner ends of the primary septa. The outer ("interseptal") area is occupied by more or less convex cellular tissue, convexity upwards and inwards, and arranged in oblique rows.

This genus has been known to me for upwards of twenty-four years. They form so natural and so well-marked a group that their identification can at all times be easily recognised, even with the most cursory knowledge of the corals of the carboniferous system; but I have delayed publishing the results of my own observations until I had procured all the evidence that my time would admit of. Before, however, I finally decided to place the results of my investigations on record, I went to Paris and examined the type specimens of M. Edwards and J. Haime, and also examined the specimens referred to by these authors that are in the Museums of London and Bristol; also the collection in the Dublin Museum, and all the private collections that I had access to; and had the advantage of the examination of three collections from different parts in the three Kingdoms that have been sent to me for the purpose of identification and naming; and have thus some little confidence in approaching the definition of the group. I am well aware that in this, as in all the other groups of coralline remains, there are difficulties that present themselves in their identification arising from the near affinities of the extreme forms to their nearest ally; and also from the fact that M'Coy, in his work on Palæozoic Fossils, 1851, asserts that one of the species of the group did belong to the genus *Clisiophyllum*—a statement which I hope to show is untenable when I come to treat on the latter genus. I was further induced to delay in consequence of M. Edwards and J. Haime having established the genus *Aulophyllum* for another variety. This type specimen is in the Bristol Museum, but from the fact that this specimen is uncut, and therefore could not be identified with any degree of certainty from the examination I did give it, and from the definitions by these authors in the Trans. of the Palæon. Soc., 1850-4, I am persuaded that the original coral figured by the Rev. D. Ure, in the "History of Rutherglen and East Kilbride," has no generic relation to the genus *Aulophyllum*.

As regards the relationships of the genus, *Cyclophyllum* may be said to be distinguished by characters of an unusually pronounced nature. In some of the passage forms (Pl. III., Fig. 4), in one respect, it is nearly allied to the genus *Rhodophyllum* (Pl. VII., Fig. 8), in the arrangement of the lamellæ in the centre of the visceral chamber, but it is distinctly separated from that genus by the possession of the depression in the crown of the columella presenting the aspect of a double cup; and the columella is always separated from the inner ends of the primary septa by a system of curved plates, which curve and fold round, and form the wall of the columella. In *Rhodophyllum* the crown of the columellarian area is dome-shaped, and formed by a system of sub-convolute lamellæ, which fold round an imaginary axis in the centre of the visceral chamber, and the lamellæ arise from the inner ends of the primary septa. Pl. III., Figs. 7-9 and 10 have a near affinity to the genus *Cymatiophyllum* (Thomson, Pl. VII., Fig. 5). These are, however, separated from the latter in the possession of the depression in the crown of the columella and the wall that forms its periphery. In Figs. 9 and 10 the wall is less dense. The central area is, however, separated from the inner ends of the septa, but not so pronounced as in all the other species, and so may be regarded as the passage forms of the genus.

Cyclophyllum Fungites. Ure.

Plate II., Figs. 1, 1A, and 1B.

Specific Characters.—Corallum simple, moderately tall, cylindro-conical, and curved. The epitheca is moderately stout. There are encircling lines and shallow annulations of growth. The calice is imperfect. A portion of the upper extremity of the periphery is eroded away. The central area is cup-shaped and prominent. There are sixty-six primary, alternating with an equal number of secondary, septa. The primary septa are bilamellar for four-fifths of their length from their inner ends. The outer ends are thin and single, and each is laterally united by rectangular interseptal dissepiments, which are few in number in the ("interlocular") area, and numerous towards the periphery. There are twelve interlamellar striæ in the space of a line, which, in a longitudinal section, are seen to extend inwards and downwards (Fig. 1B). The central area is obovate, five lines in diameter, and pointed towards the fossula, and exposes the cut ends of the endothecal septa around the inner margin of the inner cup-shaped projection, and its wall is united to the inner ends of the primary septa by the intervention of a system of curved plates, which, at their inner ends, fold round and form the wall of the tubular columella.

The longitudinal section is triareal (Pl. II., Fig. 1B); the central area exposes discontinuous vertical columellarian plates, and each is united by minute convex tabulæ, and the wall of the tubular columella is formed by a system of sub-convolute plates, which extend from the inner ends of the primary septa. These, at their inner ends, recurve, fold round, and form the wall of the tubular columella. The intermediate ("interlocular") area is broad, and occupied by more or less convex tabulæ. The outer ("interseptal") area is occupied by irregular lenticular convex cells, pointing upwards and inwards, and arranged in oblique rows. The fossula is small, and one of the primary septa, half the length of the others, extends into it.

Height of corallum, 2 inches 4 lines; diameter of section, 1 inch in the longest angle and 11 lines in the shortest angle.

Formation, Carboniferous ; Locality.—I am unable to say precisely in what locality in East Kilbride this interesting corallum was found. During the last fifteen years I have visited many localities in the parish of East Kilbride, and have discovered in the form of Shells specimens similar in structure, fossilization, and preservation, and I am therefore persuaded that this specimen was found in the neighbourhood of the locality.

The above are sections and a cast of the coral figured by the Rev. David Ure in his "History of Rutherglen and East Kilbride," and named by him Fungites (page 325, plate 20, fig. 6), and now in the collection of the Royal Society of Edinburgh.

Plate II. Fig. 2 is an impression of a longitudinal section of a corallum. The section is cut down the central axis, to show the structural details of an entire corallum and the cup-shaped crown of the tubular columella.

Cyathophyllum Crassum. Thomson. Sp. nov.

Plate II., Fig. 3, 3a.

Specific Characters.—Corallum simple, moderately tall, cylindro-conical and slightly curved. The epitheca is thin, and the septa protrude through it and are exposed in delicate longitudinal ridges. There are encircling lines, and broad, shallow annulations of growth. The calice is circular, and moderately everted around the margin of the periphery. The crown of the columella is slightly raised above the inner ends of the primary septa, and the cup-shaped depression in the superior extremity of the columella is moderately deep. The septa are moderately stout, and bilamellar for four-fifths of their length from their inner ends, and single around the periphery. There are ten interlamellar rectangular plates in the space of a line, which are the cut ends of the interlamellar striæ, and are seen in the longitudinal section, extending inwards and downwards Fig. 3B). There are sixty-eight primary, alternating with an equal number of secondary, septa, which extend inwards from the periphery for fully half the length of the primary, and each is united by rectangular interseptal dissepiments, which are dense in the outer area and few in number near the inner ends of the primary septa. The central area is circular, and is five lines in diameter, and in transverse section exposes the cut ends of forty-eight minute septa around the periphery of the columella. These converge inwards, coalesce, and form a reticulate endothecal tissue in the centre of the central area. The space between the endotheca and the inner ends of the primary septa is nearly a line broad, and is occupied by sub-convolute plates, which extend from the inner ends of the primary septa, fold round, and form the wall of the tubular columella. The fossula is moderately large, and three of the primary septa, of shorter length than the others, extend into it. The central septum is considerably shorter than its two neighbours. The longitudinal section is triareal. (Pl. II., Fig. 3.) The central area is occupied by more or less discontinuous plates, which intersect the dense endothecal tissue of the central area, and the outer margin is occupied by delicate ascending plates. These are attached to a system of plates which curve, and pass downwards, around the inner margin of the cup in the crown of the columella. Some of these unite and extend to the centre of the visceral chamber, and exhibit a dense vesicular tissue; and the outer margin of the wall is formed more or less of sub-convolute plates. A portion of them extend outwards, and are attached to the inner ends of the primary septa. The intermediate ("interlocular") area is broad, and occupied by convex tabulæ; the outer ("interseptal") area is occupied by convex cells, convexity pointing inwards and upwards, and arranged in oblique rows.

The fossula is of moderate dimensions, and one of the primary septa, of shorter length than the others, extends into it, and a portion of the endothecal structure extends into it.

Height of corallum, 3 inches. There is a small portion of the inferior extremity awanting—probably about three-quarters of an inch. Diameter of calice, fully an inch.

Formation, Carboniferous; Locality.—Found in a band of shale that overlies the lowest bed of limestone at Petershill Quarry, near Bathgate, Linlithgowshire.

I have great pleasure in naming this species in memory of the late Rev. David Ure, the author of that interesting work, "The History of Rutherglen and East Kilbride."

Plate II., Fig. 4, represents a weathered specimen exposing the tubular columella in the central area. Found at Cunningham Bedland Quarry, near Dalry, Ayrshire.

Cyclophyllum Bowerbankii. Duncan and Thomson.

Plate II., Figs. 5, 5A.

Specific Characters.—Corallum simple, imperfect, cornute, and curved; calice awanting, epitheca thin, with encircling lines and broad shallow annulations of growth. The primary septa are stout, and bilamellar for four-fifths of their length from their inner ends. There are eight interlamellar rectangular plates in the space of a line, which are the cut ends of the interlamellar striæ, and are seen in the longitudinal section extending inwards and downwards. The primary septa are single and thin in the outer area. There are sixty-eight primary, alternating with an equal number of secondary septa: the latter extend inwards from the periphery for about half the length of the primary, and each is united by rectangular interseptal dissepiments, which are numerous in the outer area and few in number near their inner ends. The central area is circular, and acuminate opposite the fossula, and is six lines broad, and exposes the cut ends of a system of dense columellarian septa, which converge inwards from the periphery, coalesce, and a portion of them extend into the centre, and form the vesicular tissue in the centre of the tubular columella, and each is united by minute interseptal dissepiments. The wall is formed of convex endothecal plates, convexity pointing outwards, and surrounded by a zone of curved plates, which unite the columella to the inner ends of the primary septa. The fossula is moderately large, and one of the primary septa, of shorter length than the others, extends into it.

In the longitudinal section there is a space about the middle of the corallum where the normal structure is wanting. It is occupied with carbonate of lime. This carbonate of lime is crystallised in a mass, which breaks up in irregular prisms; but whether the structure has been displaced by fossilisation, or during the life of the polyp, or if the secretion of the structure had been interrupted by the intervention of some foreign body, I am not prepared to decide. The latter seems more probable. That such is possible is exemplified in Plate III. Fig. 3, where the secretion of a portion of the septa has been temporarily interrupted.

The longitudinal section is figured Pl. II. Fig. 3a. The central area is broad, and is occupied by minute and dense discontinuous vertical plates, which are the cut ends of the septa that surround the periphery of the columella, and each is united by minute tabulæ. The wall is formed of convex endothecal plates, which point upwards, and at their upper ends curve downwards over the floor of the cup at the crown of the tubular columella, and united to the inner end of the primary septa by the intervention of a system of plates which, at their inner ends, fold round and clasp the wall of the columella. The intermediate ("interlocular") area is occupied by irregular convex tabulæ. The outer ("interseptal") area is occupied by convex cells, convexity pointing inwards and upwards, and arranged in oblique rows.

Height of corallum, imperfect, 1½ inches; diameter of section, 1 inch 3 lines.

Formation, Carboniferous; Locality.—Found in a band of shale that overlies the lowest bed of limestone at Gameshill Quarry, near Dunlop, Ayrshire.

Cyclophyllum biacuminatum. Thomson. Sp. nov.

Plate II., Fig. 6.

Specific Characters.—Corallum simple, moderately tall, cylindroconical, curved; calice, imperfect; shallow transverse section elliptical; epitheca thin, with crenulate encircling lines and shallow and broad annulations of growth. The septa are moderately stout, and bilamellar for two-thirds of their length from their inner ends. There are eight interlamellar rectangular plates in the space of a line, which are the cut ends of the interlamellar striae, and are seen in the longitudinal section converging inwards and downwards. The septa are single and slightly flexuous in the outer area. There are fifty-eight primary, alternating with an equal number of secondary, septa. The latter extend inwards from the periphery for fully the half length of the primary, and each is united by rectangular interseptal dissepiments in the outer area, and few in number in the intermediate ("interlocular") area. The central area is elliptical in outline, and acuminate at each end of the long angles, and extends into the fossula on the ventral side of the corallum, and on the dorsal side the acuminate projection extends into the double or false fossula. The wall is formed of convex endothecal tissue, convexity pointing outwards, and united to the inner ends of the primary septa by the intervention of a system of minute angular plates. Around the inner margin of the periphery is occupied by delicate septa. These converge inwards, coalesce, and a portion of them extends into the centre of the central area, and each is united by minute interseptal dissepiments, and exhibits in the centre a reticulate endothecal tissue. The central area is 7 lines long and 4 lines broad. The fossula is large on the ventral side, and two septa extend one line into it from the periphery, and on the dorsal side the fossula (false fossula) is small, and one of the primary septa, a half line shorter than the others, extends into it.

Height of corallum, 3 inches; diameter of section, fully 1 inch at the longest, and 11 lines at the narrowest.

Formation, Carboniferous; Locality.—Found in Roughwood Quarry, Beith, Ayrshire.

The dense endothecal tissue, the elliptical and bicuminate aspect of the central area, warrants this form being recorded as a distinct species.

Cyclophyllum pachyendothecum. Thomson. Sp. nov.

Plate II., Fig. 7.

Specific Characters.—Corallum simple, stout, moderately tall, conical, and curved. The epitheca is thin. The exterior margin of the septa is visible from without through the thin epithecal covering. The calice is shallow and circular, and in its centre the cup is shallow and broad. The septa are stout, and bilamellar for four-fifths of their length from their inner ends, and there are nine interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ, which converge inwards and downwards. The septa are thin towards the periphery. There are seventy-six primary, alternating with an equal number of secondary, septa; the latter extend inwards from the periphery for half the length of the primary, and each is united by rectangular interseptal dissepiments, which are dense towards the periphery and few in number in the intermediate ("interlocular") area. The fossula is small, and a portion of the endothecal tissue extends into it. The central area is broad, circular, and acuminate at the mouth of the fossula, and is six lines broad. The endothecal wall is stout. The septa are minute and dense around the periphery; they extend inwards for a line, they then coalesce and become fasciculate, and the central septum of each fascicula extends in towards the central area. They then unite, and form a reticulate cellular tissue in the centre of the central area. The endotheca is united to the inner ends of the primary septa by the intervention of a system of angular plates. The fossula is moderately large, and two of the primary septa, of shorter length than the others, extend into it.

Height of corallum, $2\frac{1}{2}$ inches; diameter of section, 1 inch 4 lines.

Formation, Carboniferous; Locality.—Found in a band of shale that overlies the lowest bed of limestone at Brockley, near Lesmahagow.

The stout, prominent endothecal wall and stout septa separate this species from *Cy. Bowerbankii*, its nearest ally.

Cyclophyllum obovatum. Thomson. Sp. nov.

Plate II., Fig. 8.

Specific Characters.—Corallum simple, moderately tall, conical, and curved. The epitheca is thin, with encircling lines and irregular, shallow annulations of growth. The calice is circular and moderately deep, and the central cup projects above the inner ends of the primary septa. The primary septa are moderately stout, and bilamellar for four-fifths of their length from their inner ends, and have nine interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ. The septa are more or less flexuous. There are sixty-four primary, alternating with an equal number of secondary septa. The latter extend inwards from the periphery for fully half the length of the primary, and each is united by angular interseptal dissepiments. The central area is obovate, and acuminate opposite the fossula, and three and a half lines broad and four and a half lines long. The endotheca is composed of convex cells, convexity pointing outwards, and there is a zone of dense minute septa, which extend inwards from the periphery for three-fourths of a line. They then coalesce, and a portion of them converge into the central area of the visceral cavity. The endotheca is united to the inner ends of the primary septa by the intervention of a system of large cellular tissue. Some of these are convex, convexity pointing outwards, while others are more or less angular. The fossula is moderately large, and one of the primary septa, half the length of the others, extends into it.

Height of corallum, 3 inches; diameter of calice, 1 inch 2 lines.

Formation, Carboniferous; Locality.—Found in the coralline band of impure limestone in Trearn Quarry, near Beith, Ayrshire.

This species is readily distinguished from the preceding by the broad zone between the inner ends of the primary septa and the wall of the tubular columella, and the obovate aspect of the superior extremity, and by the short and dense septa around the periphery of the columella.

Cyclophyllum Scoulerianum. Thomson. Sp. nov.

Plate II., Fig. 9.

Specific Characters.—Corallum simple, tall, conical, and curved, with deep encircling lines, and irregular, broad, shallow annulations of growth. The calice is wanting. The primary septa are bilamellar to near the periphery; they are then thin, and there are ten interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ, which converge inwards and downwards. There are sixty-four primary, alternating with an equal number of secondary septa. The latter extend inwards for fully half the length of the primary septa, and each is united by more or less angular interseptal dissepiments, which are dense in the outer zone and few in number in the inner ("interlocular") area. The central area is sub-circular, and fully five lines broad and fully four lines long, and there is a prominent triangular projection extends into the fossula. The wall is occupied by lenticular convex plates, convexity pointing outwards. The inner margin of the periphery is surrounded by a system of septa which extend inwards for a line. They then coalesce and converge into the centre, and form a dense reticulate cellular tissue in the centre of the central area. The wall is united to the inner ends of the primary septa by the intervention of a broad zone of large irregular cellular tissue. The fossula is moderately large, and one of the primary septa, half the length of the others, extends into it.

Height of corallum, imperfect, 3 inches; diameter of section, 1 inch 4 lines.

Formation, Carboniferous ; Locality.—Found in a band of shale that overlies the lowest bed of limestone at Brockley, near Lesmahagow, Lanarkshire.

This species differs from all the preceding by the smaller central area, its sub-circular outline, and the dense vesicular tissue which occupies the tubular columella; and it gives me great pleasure to dedicate it to the memory of my old and valued friend, the late Dr. John Scouler, who, with many other kind favours, suggested *Diplocyathophyllidæ* as an appropriate name for the family in which this genus is included.

Cyclophyllum Duncanianum., Thomson. Sp. nov.

Plate II., Fig. 10.

Specific Characters.—Corallum simple, tall, conical, and curved. The epitheca is thin, with crenulate encircling striæ, and irregular and broad shallow annulations of growth. The calice is circular and shallow, and everted near the periphery, and the centre of its floor is occupied by a narrow and shallow cap-shaped projection. The primary septa are bilamellar for four-fifths of their length from their inner ends, and there are ten interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ. The septa are thin and single towards the periphery. There are seventy primary, alternating with an equal number of secondary, septa. The latter extend inwards from the periphery for three-fifths of the length of the primary septa, and each is united by rectangular interseptal dissepiments, which are numerous in the outer ("interseptal") area and few in number in the intermediate ("interlocular") area. The central area is sub-circular, and four lines broad and five lines long, and the wall is composed of lenticular plates, and is attached to the inner ends of the primary septa by the intervention of a zone of irregular plates, which are few in number, exposing a broad space between the septal system and the columella. The inner margin of the periphery is occupied by a system of irregular septa, which extend inwards for nearly two lines. They then coalesce and converge inwards and become united, and exhibit a reticulate cellular tissue in the centre of the central area. The fossula is large, and two of the primary septa, of shorter length than the others, extend into it.

Height of corallum, 4 inches; diameter of calice, 1½ inch.

Formation, Carboniferous; Locality.—Found in a bed of shale that is interstratified between the thin beds of limestone near the base of the lower limestone at Brockley, near Lesmahagow, Lanarkshire.

This species is distinguished from *Cy. Scoulerianum* by the more delicate septa, its rectangular dissepiments, its larger fossula, and in the absence of the acuminate projection in the central area, and the large irregular plates, and by its larger septa in the columellar area; and I have great pleasure in naming it in honour of Prof. Peter Martin Duncan, F.R.S., my colleague in the establishment of the genus.

Cyclophyllum ellipticum. Thomson. Sp. nov.

Plate II., Fig. 11.

Specific Characters. — Corallum simple, short, and cylindro-conical. The epitheca is thin and marked with delicate encircling lines and irregular and broad annulations of growth. The calice is circular and shallow; and the septa are everted in the outer area. The central area projects slightly above the inner ends of the primary septa. The septa are bilamellar for nearly their total length from their inner ends, while around the periphery they are single. There are nine interlamellar plates in the space of a line. There are fifty-two primary, alternating with an equal number of secondary, septa. The latter extend inwards from the periphery for nearly three-fourths of the total length of the primary septa, and all are united by more or less rectangular interseptal dissepiments, which are dense in the outer ("interseptal") zone and sparse in the intermediate ("interlocular") area. The central area is elliptical in outline, two lines broad and three and a half lines long. The wall is formed by lenticular cellular tissue, and united to the primary septa by sparse convex plates. There is a cycle of minute septa around the inner margin of the periphery, which are hardly recognisable amongst the dense endothecal tissue they intersect, and a portion of them converge inwards, and are more or less flexuous, and presents a dense and reticulate tissue in the centre of the central area. The fossula is large, and two of the primary septa, of shorter length than the others, extend into it.

Height of corallum, 2 inches; diameter of calice, 10½ lines long and 8½ broad.

Formation, Carboniferous; Locality.—Found in Roughwood Quarry, near Beith, Ayrshire.

This species is readily distinguished by the elliptical outline of the central area, and by the secondary septa, which are much longer than is usually present in the most of the other species.

Cyclophyllum orbiculum. Thomson. Sp. nov.

Plate II., Fig. 12.

Specific Characters.—Corallum simple, turbinate, and curved. The epitheca is thin and marked with stout encircling lines and broad, shallow annulations of growth. The calice is deep and thin around the periphery, and the cup-shaped crown of the columella is prominently projected above the inner ends of the primary septa. The septa are of two orders. The primary are stout, and bilamellar for four-fifths of their length from their inner ends; and in the outer area they are single and thin, and there are seven interlamellar plates in the space of a line. There are fifty-six primary, alternating with an equal number of secondary septa; and all are united by interseptal dissepiments, which are rectangular and delicate in the outer ("interseptal") zone, and in the intermediate ("interlocular") area they are few in number. The central area is small and orbicular; the wall is formed by lenticular cells, and is united to the inner ends of the primary septa by a system of large irregular plates, which extend across the deep groove, and fold round and clasp the wall. The septa around the inner margin of the endotheca are dense. They extend inwards for a line. They then coalesce, and assume a more or less fasciculate aspect. The central septum of each fascicle converges inwards and unite in the centre, and all are united by minute endothecal tissue, and presents a reticulate structure in the centre of the central area. The fossula is conspicuous, and two of the primary septa extend into it.

Height of corallum, 2 inches; diameter of calice, 1 inch 1 line.

Formation, Carboniferous; Locality.—Found in the coralline band of impure limestone at Trearn Quarry, near Beith, Ayrshire.

The small orbicular central area is so widely different from any of the other species, I feel it is unnecessary to say more regarding it.

Cyclophyllum Carpenterianum. Thomson. Sp. nov.

Plate III., Fig. 1, 1A.

Specific Characters.—Corallum simple, tall, cylindrical, and curved. The epitheca is thin, and marked with encircling lines and shallow annulations of growth. The calice is circular and everted. The central area is broad, and if the cup of the vertical section had been cut along its central axis, would have presented the aspect of a deep inverted cone. The corallum is slightly recurved; consequently, at the superior extremity the vertical section exposes the structure of the peripheral zone, while towards the lower extremity the septa are seen converging inwards and downwards. The septa are delicate and of two orders. The primary are bilamellar for four-fifths of their length from their inner ends. In the outer zone they are single and thin. There are eight interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ, which are seen in the longitudinal section to extend inwards and downwards. There are eighty primary, alternating with an equal number of secondary septa; the latter extend inwards from the periphery for fully half the length of the former, and all are united by minute rectangular interseptal dissepiments in the outer zone, and in the intermediate area they are few in number. The central area is sub-circular, and exposes the cut ends of the dense endothecal tissue of the tubular columella. The wall is composed of small convex cells, convexity pointing outwards. There is a cyclum of delicate and numerous septa around the inner margin of the periphery, and all are united by the dense endothecal tissue they intersect; some of the septa coalesce and unite, and become more or less fasciculate; and the central septum of each fascicle extends into the centre of the central area, where they unite. These are again united by endothecal tissue, and compose a dense reticulate structure in the centre of the central area. The fossula is moderately large, and one of the primary septa, half the length of the others, extends into it.

The longitudinal section is triareal (Pl. III., Fig. 1). The central area is broad. In the centre of the central area there are exposed the cut edges of the columellar septa, converging inwards and downwards to the centre, and usually the septa of each side of the columella meet at their lower ends, and in outline present the aspect of an inverted conical formed cup. These septa are more or less indistinct from the dense endothecal tissue they intersect. The peripheral zone is occupied by the outer ends of the septa and the dense endothecal tissue, and their outer ends are enveloped by a zone of convex cells, convexity pointing outwards, and forming the wall of the broad tubular columella. The intermediate ("interlocular") area is occupied by convex tabulæ, convexity pointing upwards and inwards. These tabulæ are frequently concealed by the interlamellar striæ arising from the curvature of the corallum, and thus the interlamellar spaces are more or less exposed (Pl. III., Fig. 1B). The curvature of the corallum is rendered greater by the fact that it has been injured, and the fracture extends to near the opposite side of the corallum, as presented in the structureless portion near the lower end of the section. The outer ("interseptal") area is occupied by minute convex cells, convexity pointing inwards and upwards, and arranged in oblique rows.

Height of corallum, imperfect; the specimen is 3½ inches long; diameter of calice, 1 inch 4 lines in the long angle.

Formation, Carboniferous; Locality.—Found in a band of shale that is interstratified between the two lowest of the thin beds of limestone, near the base of the carboniferous limestone on the banks of the Poneil Water. Brockley, near Lesmahagow, Lanarkshire.

This is the only specimen of this species that I have seen in Scotland. It is found, however, near Richmond and Lancaster, in England. It was sent to me for naming by the late Mr. Wood, of Richmond, and I saw it in a small collection belonging to a gentleman from Lancaster, and exhibited at the meeting of the British Association in York, 1881. It is, therefore, all but unique, and I have great pleasure in naming it in honour of Dr. William B. Carpenter, C.B., LL.D., F.R.S., the distinguished physiologist, as an expression of my thanks for recent and former kindnesses.

Cyclophyllum Bennieanum. Thomson. Sp. nov.

Plate III., Figs. 2, 2A, 2B, and 2C.

Specific Characters.—Corallum simple, moderately tall, cylindro-conical, and curved. The epitheca is thin. There are encircling lines, and broad, irregular annulations of growth, and here and there we find dispersed elongated depressions, which are indicated by the deep indentations around the periphery in the transverse sections. The calice is circular and moderately deep, and in the centre of its floor the cup-shaped projection is slightly elevated above the inner ends of the primary septa, and the septa around the inner margin of the periphery of the columella are seen converging inwards and downwards, and a portion of them extend into its centre. The septa are more or less clavate at their inner ends, and bilamellar for three-fourths of their length from the inner ends and single and thin around the peripheral zone. There are ten interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ. There are forty-eight primary septa in the section taken from the superior end, and forty-four primary septa in the section from near the inferior extremity of the corallum, alternating with an equal number of secondary septa. The latter extend inwards from the periphery for a third of the length of the primary, and each is united by a narrow zone of interseptal dissepiments in the outer area, and in the intermediate ("interlocular") area they are few in number. The central, columellarian area is sub-circular and acuminate, and the acuminate portion extends into the fossula. The wall is composed of convex cells, convexity pointing outwards, and united to the inner ends of the primary septa by the intervention of a zone of irregular plates, which at their inner ends fold round the wall. There is a system of septa around the inner margin of the periphery. These extend inwards for a line. They then coalesce, and a portion converge, inwards to the centre of the central area, and all are united by the dense endothecal tissue they intersect. The fossula is medium in size, and one of the primary septa, fully a third of the length of the others, extends into it.

Height of corallum, 2½ inches; diameter of calice, 10 lines.

Formation, *Carboniferous; Locality.*—Found at Roughwood Quarry, near Beith, Ayrshire. It is also found at Sheills, East Kilbride.

This corallum is cut into six different sections—three of these are represented—and I believe that any palæontologist, with even the most superficial knowledge of coralline structure, will see that the specific characters are persistent and distinct from the superior to the inferior extremity of the corallum.

This species is distinguished from *Cy. Bowerbankii*, its near ally, by the fact that the corallum is never found as large, and is always thinner and more cylindrical, and the structure in the central area is never so dense, and the cellular tissue of its wall is always more compact, and may be said to be an intermediate variety between *Cy. Bowerbankii* and *Cy. pachyendothecum;* and I have great pleasure in naming it in honour of Mr. James Bennie, of the staff of the Geological Survey of Scotland, and as an expression of my thanks for his kindness in aiding me in discovering what I believe is the locality where the Rev. David Ure procured the type specimen.

Cyclophyllum M'Kendrickianum. Thomson. Sp. nov.

Plate III., Fig. 3.

Specific Characters.—Corallum simple, imperfect, conical, and curved. The epitheca is thin, and the exterior margin of the septa is visible from without through the thin epithecal covering. The calice is wanting. The septa are somewhat irregular and moderately stout. The primary septa are bilamellar for four-fifths of their length from the inner ends, and single and thin around the periphery. There are nine interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ. There are sixty-two primary, alternating with an equal number of secondary septa, and all are united by rectangular interseptal dissepiments, which are numerous in the outer ("interseptal") zone and sparse in the intermediate ("interlocular") area. A portion of the septa are interrupted by a foreign body, which indicates that that body had been absorbed by the tentacles of the polyp interrupting the secretion of the calcareous matter of which the coralline structure is composed. The tentacles would seem to have imbedded this body and folded over it, then the parts coalescing and assuming the normal aspect; as, in order to know how deep this foreign body was imbedded, I cut the section about an eighth of an inch below, and found only a small portion of the recurved end of one of the septa. All the other tentacles had assumed their normal form, the septa being similar in outline to the others. The central area is large in proportion to the total diameter of the corallum, and is sub-circular in outline. The wall is formed by convex cells, convexity pointing outwards, and attached to the inner ends of the septa by the intervention of a system of irregular plates. There is a system of septa which extend inwards for a line. They then coalesce, and become fasciculate, and the central septum of each fascicle converges inwards to the centre, and all are united by the dense endothecal tissue they intersect. The fossula is small, and one of the primary septa, of shorter length than the others, extends into it.

Height of corallum imperfect; specimen, 2½ inches; diameter of section, 11 lines.

Formation, Carboniferous; Locality. — Found at Petershill Quarry, near Bathgate, Linlithgowshire.

This species differs from *Cy. Ureanum*, its nearest ally, by its dense endothecal tissue, and its irregular and stouter septa, and its less-marked fossula; and it gives me great pleasure in dedicating it in honour of Professor John G. M'Kendrick, M.D., LL.D., to whom I offer my cordial thanks for his uniform kindness.

Cyclophyllum curvilineare. Thomson. Sp. nov.

Plate III., Fig. 4.

Specific Characters.—Corallum simple, imperfect, cylindrical. The epitheca is thin, and there are encircling lines and shallow annulations of growth. The septa are delicate and numerous. The primary septa are bilamellar for four-fifths of their length from their inner margins, and in the outer area they are thin and single. There are ten interlamellar plates in the space of a line. There are seventy-two primary, alternating with an equal number of secondary septa. The latter extend inwards for a third of the length of the primary septa, and all are united by minute rectangular interseptal dissepiments, which are dense in the outer ("interseptal") area and few in number in the intermediate ("interlocular") area. The central area is irregular in outline, and the septa are scarce, and are more or less curvilinear. The wall is composed of lenticular curved plates, and is united to the inner ends of the primary septa by the intervention of a system of irregular plates, which extends across the broad groove that separates the upper extremity of the columella from the inner ends of the septa. The centre of the central area is occupied by irregular and scarce endothecal tissue. The fossula is large, and two of the primary septa, of shorter length than the others, extend into it.

Height of corallum, imperfect; specimen, 1½ inch; diameter of section, 11 lines.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone at Petershill, near Bathgate, Linlithgowshire.

This remarkable species is distinguished from all the other species by characters of an unusually distinct kind, and may be regarded as an intermediate form between the genus *Cyclophyllum* and the genus *Rhodophyllum* (Pl. VII., Fig. 8). The septa have all the characteristics of *Cyclophyllum*, as it is only from the structural character of the central area that we can define either genera or species; and, while there is a near affinity in the curviline character of the endothecal tissue to the sub-convolute lamella in *Rhodophyllum*, yet they are separated by characters of a fundamental nature. In *Rhodophyllum* the lamellæ are more or less united to the inner ends of the primary septa, and they curve round an imaginary axis, and are united by scarce endothecal tissue, and there is no wall around the columellarian area. While in *Cyclophyllum* there is a more or less broad groove around the columella, there is always an endotheca formed of convex cells, and united to the inner ends of the primary septa by the intervention of a system of plates, and there is always a cycle of septa, more or less dense, around the inner margin of the mural covering. These converge into the centre of the central area, and present a more or less reticulate structure, and I believe upon the whole the structural characters of this species have closer affinities to the latter, and therefore must be placed in that genus.

Cyclophyllum concentricum. Thomson. Sp. nov.

Plate III., Fig. 5.

Specific Characters.—Corallum simple, moderately tall, cylindroconical, and curved. The epitheca is thin, and the septa are visible through the thin epithecal covering. There are encircling lines and irregular annulations of growth. The calice is circular and shallow, and the crown of the columella is slightly raised above the inner ends of the primary septa. The septa are bilamellar for four-fifths of their length from their inner ends. In the outer zone they are single and thin. There are six interlamellar plates in the space of a line. There are forty-eight primary, alternating with an equal number of secondary septa. The latter are irregular in the length, but usually extend inwards from the periphery for half the length of the primary, septa, and all are united by rectangular interseptal dissepiments in the outer zone, and in the intermediate ("interlocular") area they are few in number. The central area is spherical, and the wall is composed of lenticular and slightly convex cells, convexity pointing outwards, and united to the inner ends of the primary septa by the intervention of a system of irregular plates, which at their inner ends fold round, and clasp the wall of the columella. There is a system of septa which converge inwards from the periphery to the centre of the central area, and are united by sparse endothecal tissue. The fossula is large, and one of the primary septa extends about two-thirds of the length of the others into it.

Height of corallum, 2½ inches; diameter of section, 9 lines.

Formation, Carboniferous; Locality.—Found in a band of shale that overlies the lower bed of limestone at Gameshill Quarry, near Dunlop, Ayrshire.

This species differs from *Cy. cylindricum*, its nearest ally, by its smaller central area, and by the arrangement of the septa in the central area. They are less in number, and nearly all of them converge to the centre, assuming a concentric aspect.

Cyclophyllum cylindricum. Thomson. Sp. nov.

Plate III., Fig. 6.

Specific Characters.—Corallum simple, tall, thin, cylindrical, and twisted. The epitheca is thin, and marked with flexuous lines and shallow and broad annulations of growth. The calice is circular and shallow, and the cup-shaped crown of the columella projects above the inner ends of the primary septa. The primary septa are stout, and bilamellar for four-fifths of their length from their inner margins, and single and thin around the periphery; and there are eleven interlamellar plates in the space of a line, which converge inwards and downwards. There are fifty-four primary, alternating with an equal number of secondary septa. The latter extends inwards from the periphery for about a third of the length of the primary, and all are united by rectangular interseptal dissepiments, which are not so numerous in the outer ("interseptal") zone as is usually found in this group, and few in number in the intermediate ("interlocular") area. The central area is more or less spherical, and acuminate opposite the fossula; and the wall is composed of convex cellular tissue, convexity pointing outwards. There is a cyclum of septa around the inner margin of the periphery, the majority of which converge inwards to the centre, and all are united by interseptal dissepiments. These septa are irregularly developed, and greatly less in number than in any of the previous species, and the central area is reticulate. The fossula is large, and one of the primary septa, of shorter length than the others, extends into it, and a portion of the central area passes into it.

Height of corallum, 7 inches; diameter of section, 11 lines.

Formation, Carboniferous; Locality.— Found in Petershill Quarry, near Bathgate, Linlithgowshire.

This species is readily distinguished by its tall cylindrical aspect, by the shallow calice, and the greatly less dense vesicular tissue in the central area.

Cyclophyllum frondicum. Thomson. Sp. nov.

Plate III., Fig. 7.

Specific Characters.—Corallum simple, short, turbinate, and curved. The epitheca is stout, and there are encircling lines and shallow annulations of growth. The calice is deep and everted. The central area is concealed. The septa are of two orders. The primary are bilamellar for two-thirds of their length from their inner ends, and around the outer zone they are frondescent. There are twelve interlamellar plates in the space of a line. There are forty-eight primary, alternating with an equal number of minute secondary septa, which are hardly recognisable in the dense vesicular tissue they intersect in the outer zone, and all are united by angular interseptal dissepiments in the outer ("interseptal") zone, and few in number in the intermediate ("interlocular") area. The central area is broad, and its wall is formed by large lenticular cells, and united to the inner ends of the primary septa by the intervention of a system of angular plates. The septa extends inwards from the periphery to near the centre, where they coalesce, and a portion extends to the centre, and all are united by endothecal tissue, and exhibits a dense mass of vesicular structure in the centre of the central area. The fossula is small, and one of the primary septa, slightly shorter than the others, extends into it.

Height of corallum, 2 inches; diameter of calice, 1 inch 5 lines.

Formation, Carboniferous; Locality.—Found in cream-coloured shale that overlies the lower beds of limestone at Catcraig, near Dunbar, Haddingtonshire.

This species is so closely allied to the genus *Dibunophyllum* (Plate VII., Fig. 9) that I have long been doubtful which of the genera it ought to be classed with. The possession of the wall around the columella and the intervention of the cycle of plates that unites the columella to the inner ends of the primary septa has induced me to place it as an extreme variety of *Cyclophyllum.*

Cyclophyllum tortuosum. Thomson. Sp. nov.

Plate III., Fig. 8.

Specific Characters.—Corallum simple, moderately tall, cylindrical, and curved. The epitheca is thin, and marked with delicate encircling lines and irregular and shallow annulations of growth. The calice is wanting. The septa are of two orders. The primary are bilamellar for three-fourths of their length from their inner ends. There are nine interlamellar plates in the space of a line. There are sixty-four primary, alternating with an equal number of secondary septa. The latter extend inwards for barely half the length of the primary septa, and each is united in the outer ("interseptal") zone by delicate rectangular interseptal dissepiments, and in the intermediate ("interlocular") zone by rectangular dissepiments, which are few in number. The central area is sub-circular in outline. Its wall is composed of convex cells, convexity pointing outwards, and attached to the inner ends of the primary septa by the intervention of a system of angular plates, which at the inner ends fold and clasp round the wall of the columella. Around the inner margin of the wall there is a cycle of minute septa, which at their inner ends become tortuous, and converge to the centre of the central area, and present an irregular reticulate structure. The fossula is of moderate dimensions, and one of the primary septa, of shorter length than the others, extends into it.

Height of corallum, 5 inches; diameter of section, 1 inch 2 lines.

Formation, Carboniferous; Locality.—Found in a band of shale that overlies the lowest bed of limestone at Petershill Quarry, near Bathgate, Linlithgowshire.

This species is readily distinguished by the form and arrangement of the endothecal tissue in the central area.

Cyclophyllum paradoxacum. Thomson. Sp. nov.

Plate III., Fig. 9.

Specific Characters.—Corallum simple, moderately tall, conical, and curved. The epitheca is thin, there are encircling lines, and shallow annulations of growth. The calice is wanting. The septa are stout, and bilamellar for three-fourths of their length from their inner ends. In the outer zone they are delicate and single. There are seven interlamellar plates in the space of a line. There are forty-eight primary, alternating with an equal number of secondary septa. The latter extend inwards from the periphery for a third of the length of the primary, and all are united by a narrow zone of interseptal dissepiments in the outer area, and in the broad intermediate ("interlocular") area they are few in number. The central area is broad and sub-circular, and the wall is formed by concave plates on one side of the columella, while on the opposite side there is exposed the cut ends of a few lamellæ, which extend inwards for two lines from the inner ends of the primary septa that they are contiguous to. They then coalesce, and a portion of them converge inwards to the centre, and all are united by endothecal tissue, and present a loose reticulate structure, while the opposite side of the columella is occupied by irregular concave endothecal tissue, concavity pointing inwards, exhibiting loose cellular structure. There are thus structural characters on the one side of the central area which properly belong to the genus *Albertia,* while on the other the cellular tissue is more closely related to the genus *Cyclophyllum.* From details so much at variance I have been long in doubt as to what group this variety could be placed amongst. The structural characters of the latter genus being more abundantly represented, I have meanwhile placed it in that genus. There is a septal fossula, and two of the primary septa, of shorter length than the others, extend into it.

Height of corallum, imperfect; length of specimen, 2 inches; diameter, 1 inch 3 lines.

The section represented in Plate III., Fig. 9, is taken from three-quarters of an inch below the upper part of the corallum. The specimen is cut at three different parts, to ascertain if the structural details were continuous throughout.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone at Brockley, near Lesmahagow, Lanarkshire.

Cyclophyllum intermedium. Thomson. Sp. nov.

Plate III., Fig. 10.

Specific Characters.—Corallum simple, imperfect, cylindrical. The endotheca is concealed by a portion of the matrix it was found enveloping it. The calice is also concealed, from the same cause. The primary septa are bilamellar for three-fourths of their length from their inner ends; towards the periphery they are single and thin. There are fourteen interlamellar plates in the space of a line. There are ninety-two primary, alternating with an equal number of secondary septa. The latter extend inwards from the periphery for a line, and all are united by minute endothecal dissepiments, which are numerous in the outer area and few in number towards their inner ends. The central area is broad, and is enveloped by a wall, which is composed of irregular convex cells, convexity pointing outwards, and is united to the inner ends of the primary septa by the intervention of a system of angular plates, which at their inner ends fold round and clasp the wall of the columella. Around the inner margin of the wall there is a cyclum of septa, which converge inwards to the centre, and all are united by the endothecal tissue they intersect, and present a reticulate aspect in the centre of the central area. The septal fossula is large, and two of the primary septa, of shorter length than the others, extend into it.

Height of corallum, imperfect; the specimen is 2 inches long; diameter of section, 1 inch 2 lines.

Formation, Carboniferous; Locality.—Found in a band of shale that is interstratified with the thin beds of impure limestone, about three feet above the lowest bed of limestone, at Nettlehurst Quarry, near Beith, Ayrshire.

This species differs from all the other species of the genus in the form and arrangement of the central area. The columellar septa are less numerous, and approximate closely the genus *Rhodophyllum* in their curvilinear aspect. The endothecal covering of the columellar area, and its union to the inner ends of the primary septa by the intervention of a system of irregular plates, and the broad groove around the columella, are of themselves sufficient to warrant me in placing this species in the genus *Cyclophyllum*. It is, however, another of those forms which present transitional characters, and illustrates the importance of having a large series of specimens for examination before an approximate opinion can be expressed regarding either genera or species with any degree of satisfaction.

Cyclophyllum radianum. Thomson. Sp. nov.

Plate III., Fig. 11.

Specific Characters.—Corallum simple, imperfect, tall, cylindrical, and curved. The epitheca is thin, with encircling granular lines and irregular shallow annulations of growth. The calice is wanting. The septa are bilamellar for three-fourths of their length from their inner ends. In the outer area they are single and thin. There are eight interlamellar plates in the space of a line. There are eighty primary, alternating with an equal number of minute secondary septa, and all are united by minute and rectangular interseptal dissepiments, which are numerous in the outer ("interseptal") area, and few in number in the intermediate ("interlocular") area. The central area is broad, and ovate in outline. The wall is composed of irregular convex cells, convexity pointing outwards, and united to the inner ends of the primary septa by the intervention of a system of angular plates, which are sparse, and at their inner ends curve, fold round, and clasp the wall of the tubular columella. There is a zone of septa, which extend from the inner margin of the endothecal covering, and more or less radiates into the centre of the central area. These septa are sparse, and all are united by endothecal tissue, and exhibits an open reticulate cellular tissue in the central area. The fossula is large, and one of the primary septa, a third of the length of the others. extends into it.

Height of corallum (imperfect), 3½ inches; diameter of section, 1 inch.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone in Petershill Quarry, near Bathgate, Linlithgowshire.

This species differs from *Cy. fungites*, its nearest ally, in the form and arrangement of the central area. The endothecal septa are less numerous, and the endothecal tissue is less dense, and presents a broad irregular and open cellular tissue in the central area.

Cyclophyllum Moseleyanum. Thomson. Sp. nov.

Plate III., Fig. 12.

Specific Characters.—Corallum simple, imperfect, tall, cylindroconical, and curved. The epitheca is thin, and the exterior ends of the septa are visible through the thin epithecal covering, and there are encircling striæ and broad shallow annulations of growth. The calice is deep, and thin around the margin, and the central area freely projects above the inner ends of the primary septa. The septa are bilamellar for five-sixths of their length from their inner margins. There are twelve interlamellar plates in the space of a line. There are sixty-eight primary, alternating with an equal number of secondary septa. The primary septa are stout near their inner ends, and delicate in their outer zone, and all are united by interseptal dissepiments, which are rectangular in the outer zone and more or less angular at the inner ends of the secondary septa. These dissepiments are numerous in the outer ("interseptal") area and sparse in the intermediate ("interlocular") zone. The central area is sub-circular. The wall is composed of minute convex cells, convexity pointing outwards, and around the inner margin of the endothecal covering there is a cyclum of irregular and more or less flexuous septa. A portion of these coalesce, and the central septum converges inwards to the centre of the central area, and all are united by minute endothecal tissue, and present a reticulate cellular structure in the centre. The endotheca is united to the inner ends of the primary septa by the intervention of a system of angular plates, which at their inner ends curve, fold round, and clasp the endotheca. The septal fossula is distinct, and one of the primary septa, half the length of the others, extends into it.

Height of corallum, 6 inches; diameter of calice, 1 inch 5 lines.

Formation, Carboniferous; Locality.—Found in the coralline band of impure limestone in Trearn Quarry, near Beith, Ayrshire.

This elegant species differs from *Cy. Duncanianum*, its nearest ally, in the form and arrangement of the central area, which is more spherical, and the endothecal tissue is less dense, and the groove around the inner ends of the primary septa is not so broad, and the septa are neither so numerous and do not extend so far into the centre of the corallum; and I have great pleasure in naming it in honour of Professor H. N. Moseley, F.R.S., &c., whose "Memoirs on the Corals of the *Challenger* Expedition" have contributed so much to our knowledge of *Milleporæ*, and of the structure of the *Stylasteridæ*.

Cyclophyllum vesicularum. Thomson. Sp. nov.

Plate III., Fig. 13 and 13A.

Specific Characters.—Corallum simple, conical, and curved. The epitheca is thin, and the outer ends of the primary septa are visible through the thin epithecal covering, and it is marked with encircling lines and irregular and shallow annulations of growth. The calice is deep and thin around the periphery, and the upper margin of the tubular columella is slightly raised above the floor of the calicular cavity. The septa are bilamellar for three-fourths of their length from their inner ends, and single and thin around the peripheral zone. There are seven interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ, which are exposed in a longitudinal section, converging inwards and downwards. The septa are numerous and delicate. There are sixty-six primary, alternating with an equal number of secondary septa. The latter extend inwards from the periphery for fully the half-length of the primary, and all are united by rectangular interseptal dissepiments. These are numerous in the outer ("interseptal") half, and sparse in the intermediate ("interlocular") area. The central ("columellarian") area is broad, and exhibits the cut ends of irregular and dense endothecal tissue. The wall is composed of convex cells, convexity pointing outwards, and united to the inner ends of the primary septa by a system of angular plates, which at their inner ends curve, fold round, and clasp the endotheca. Around the inner margin of the wall there is a cyclum of minute septa. These converge inwards, coalesce, and present a more or less fasciculate aspect, and the central septum of each fascicle converges inwards to the centre, and all are united by minute and dense endothecal tissue, and present a dense vesicular structure in the centre of the central area. There are three irregular flexuous plates extending across the centre of the columella. The fossula is large, and one of the primary septa, a third of the length of the others, extends into it.

Height of corallum, 2½ inches; diameter of calice, 1 inch and 2 lines.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone in Petershill Quarry, near Bathgate, Linlithgowshire.

This species differs from *Cy. Carpentarianum*, its nearest ally, by the form and arrangement of the central area. It is neither so broad, and the endothecal tissue is not so dense, and the septa are not so numerous.

Genus Aulophyllum. Edwards and Haime.

Generic Characters.—Corallum simple, variable in height, conical, cylindro-conical, and curved. The epitheca is thin, with fine encircling lines and annulations of growth. Calice deep. In some forms it is thin around the periphery, in others they are more or less everted, exhibiting in the centre of its floor a cup-shaped projection (Fig 2A); its wall is formed by a system of curved plates

Thirdly.—There falls now to be considered the genus *Albertia*, in respect of which the only point which calls for special remark is the arrangement of the central area. In the genus *Albertia*, like that of the genus *Aulophyllum*, there is a depression in the centre of the columellarian area; it, however, never assumes the cup-shaped aspect of the latter, and there is no cylindrical tube, and the central area is occupied by a system of lamellæ, which extend inwards from the inner margin of the primary septa, and stop short of the centre, and are attached to the outer margin of the depression or shallow cup in the centre of the floor of the calice. The walls of the central depression are formed of concave tabulæ, which converge inwards and downwards, the centre of which in a longitudinal section (Pl. 4, Fig. 11a) is seen to consist of minute transverse tabulæ. The chief features that distinguish the genus *Aulophyllum* is the superior extremity of the corallum, presenting in outline the form of a double cup. In the genus *Albertia*, the calices are shallow and more or less everted, and the superior extremities of the verticle lamellæ are conspicuous, round in outline, and irregular in arrangement—a very marked distinction.

It will thus be seen that the above marked characters of the central area are sufficiently distinct to warrant the establishment of the group into a distinct genus, as the more I investigate the corals of the carboniferous rocks, the more I am persuaded that it is only in the structure of the central area that there is any classificatory value for either generic or specific distinction.

Aulophyllum Patrickianum. Thomson. Sp. nov.

Plate IV., Figs. 1 and 1A.

Specific Characters.—Corallum tall, imperfect, cylindrical, and curved. There is a portion of the lower extremity wanting, and I am therefore unable to say how it terminates. The epitheca is moderately stout, and there is irregular encircling lines and broad shallow annulations of growth. The calice is wanting. There are eighty-two primary septa. They are bilamellar for three-fourths of their length from their inner ends. In the outer area they are single, delicate, and more or less flexuous. There is an equal number of minute secondary septa, which are hardly recognisable, and all are united by irregular angular interseptal dissepiments.

There are ten interlamellar plates in the space of a line, which, in a longitudinal section, are seen to extend inwards and downwards. The central area is eleven lines in diameter, exhibiting the cut ends of the lamellæ, which extend from the inner ends of the primary septa and converge inwards along the superior face of the tabulæ, and stop short near the centre, and expose the tabulæ in the centre of the central area. The septal fossula is large, and two of the primary septa, one-third of the length of the others, extend into it.

The longitudinal section is triareal. The centre area is occupied with delicate and dense tabulæ, and at several parts there is exposed a few discontinuous lamellar plates, arising from the fact that the corallum is curved, and, in consequence of the curvature, the section is cut more or less diagonally, thereby exhibiting the lamellæ. The wall of the central area is composed of ascending convex plates, convexity pointing outwards, and at their inner ends these rest upon the tabulæ, which bend downwards into the floor of the broad flat cup. The floor of the visceral cavity is occupied by flat tabulæ in the centre. In the intermediate ("interlocular") area there are convex tabulæ, the convexity being upwards and outwards. The outer ("interseptal") area is broad, and exhibits irregular convex cellular tissue, the convexity being upwards and inwards, and arranged in oblique rows.

Height of corallum, imperfect. The portion I have is 6 inches long; diameter of section, 2 inches and 3 lines.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone in Langside Quarry, near Beith, Ayrshire.

This species may be said to be a transitional from between the genus *Albertia* and that of *Aulophyllum*. It is allied to *Albertia* by the possession of a system of lamellæ in the central area. It, however, differs from *Albertia* by the fact that the lamellæ do not intersect the tabulæ, while in *Albertia* the lamella extends from the superior to the inferior part of the corallum; and the tabulæ never extend across the central area, but are more or less intersected by the vertical lamellæ, and the centre of the central area is more or less closed in by a series of down-curved plates, and exposes loose vesicular tissue in the centre of the visceral chamber; while in *Aulophyllum* the tabulæ are seen to extend more or less across the centre of the visceral chamber in the longitudinal section, and in a transverse section the superior face of the tabulæ is always exposed in the centre of the central area, and therefore this coral possesses characters which unite it to the genus *Aulophyllum*. It gives me great pleasure in naming it in honour of R. Cochran-Patrick, Esq., M.P., LL.D., F.A.S., a gentleman who has done good work in interpretating the archæological treasures of Ayrshire, and a member of the family to whom the estate belongs in which I have found many varieties of the corals, not only of those referred to in the present communication, but also many that have been described in my former papers. A considerable number from the same property have yet to be examined.

Aulophyllum fungites. Edwards and Haime.

Plate IV., Fig. 2.

Specific Characters.—Corallum simple, moderately tall, cylindroconical, and curved. The epitheca is stout, and marked with broad encircling lines and irregular annulations of growth. The calice is imperfect. There are sixty-eight primary, alternating with an equal number of secondary septa. The latter extend inwards for half the length of the primary septa. All are united by interseptal dissepiments, which are irregular and angular near the inner ends of the secondary septa, and in the outer area around the periphery they are rectangular, and sparse in the interlocular area. The primary septa are bilamellar for three-fourths of their length from the inner ends, and single in their outer margins. There are eleven interlamellar plates in the space of a line, which in the longitudinal section are seen to extend inwards and downwards, where the interlamellar space is exposed, and where the section is more or less diagonal, arising from the curvature of the corallum. The central area is sub-spherical and acuminate opposite the septal fossula. The wall is composed of irregular lenticular convex cells, convexity pointing outwards, and is united to the inner ends of the primary septa by the intervention of a system of angular plates, which at their inner ends fold and clasp round the wall of the columella. Around the inner margin of the endotheca there is a cycle of irregular short septa. These coalesce, and extend inward along the upper face of the tabulæ, and stop short of the centre, and the tabulæ which form the floor of the visceral chamber are exposed in the centre of the central area, and the cut margins of several of the successive tabulæ are exposed around the centre, arising from the section passing transversely through the convex tabulæ. The fossula is small. One of the primary septa, three-fourths the length of the others, extends into it.

Height of corallum, 4 inches; diameter of calice, 1 inch and 1 line.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone in Petershill Quarry, near Bathgate, Linlithgowshire.

This is the type specimen described by Dr. Duncan and myself in the Quarterly Journal of the Geological Society, 1867. A *fac-simile* of the structural details is now for the first time reproduced in the accompanying plate.

Aulophyllum Edwardsianum. Thomson. Sp. nov.

Plate IV., Fig. 3.

Specific Characters.—Corallum simple, short, turbinate, and much curved near the lower extremity. The epitheca is thin, and the outer margins of the primary septa are exposed through the thin epitheca. The calice is (imperfect) deep. The central area is broad. The septa are numerous, and of two orders. There are eighty primary, alternating with an equal number of secondary septa. The latter extend inwards from the periphery for half the length of the primary, and all are united by rectangular inter-septal dissepiments, which are numerous in the outer zone and few in number in the intermediate ("interlocular") area. The primary septa are bilamellar for four-fifths of their length from their inner ends. In the outer zone, around the periphery, they are single and thin. There are nine interlamellar plates in the space of a line, which are exposed in the longitudinal section, converging inwards and downwards where the interlamellar space is exposed in the curved part of the corallum. The central area is broad, and the transverse section exposes its thin wall and the septa around its inner margin. The wall is formed of convex plates, convexity pointing outwards, and united to the inner ends of the primary septa by the intervention of a series of angular plates. The septa are long. Some of them extend inwards from its wall to near the centre of the visceral chamber, and all are united by rectangular endothecal tissue. The central space, where the tabulæ is exposed, is narrow, and the cut edges of the superimposed tabulæ are exposed around its margin. The fossula is large, and a primary septum, half the length of the others, extends into it.

Height of corallum, 2½ inches; diameter of calice, 1 inch 4 lines.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the thin band of coralline limestone near the base of the marine deposits at Brockley, near Lesmahagow, Lanarkshire.

Aulophyllum fungites. Edwards and Haime.

Plate IV., Fig. 4.

A longitudinal section, to show the double cup, the tabulæ in the central area, and the deep calicular cavity. The spaces where the structure is wanting in the interlocular area, on each side of the calice, is filled in with impure sedimentary matter, and hence obscures the structural characters.

Aulophyllum Haimeianum. Thomson. Sp. nov.

Plate IV., Figs. 5 and 6.

Specific Characters.—Corallum simple, imperfect, short, turbinate. The epitheca is thin, and the outer ends of the septal system are exposed through the epitheca. The calice is wanting. The primary septa are stout, and bilamellar for three-fourths of their length from their inner ends, and single and thin around the periphery. There are twelve interlamellar plates in the space of a line. There are fifty-six primary, alternating with an equal number of short secondary septa, and all are united by a narrow zone of rectangular interseptal dissepiments in the outer area; which in the intermediate ("interlocular") area are few in number. The central area is moderately broad and sub-spherical. The wall is formed of lenticular convex plates, convexity pointing outwards, and is united to the inner ends of the primary septa by the intervention of a system of angular plates. There is a cyclum of minute septa around the inner margin of the periphery; these coalesce, and present a more or less fasciculate aspect, and the central septum of each fascicle extends inwards, and is intercepted by the cut margins of the tabulæ near the centre. The centre of the central area is occupied by the tabulæ, which form the floor of the calicular chamber. The fossula is moderately small, and a primary septum, of shorter length than the others, extends into it, and a portion of the endotheca of the central area extends to its outer margin. Fig. 6 I regard as a young specimen of the same species.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the coralline band of limestone, near the base of the marine deposits at Brockley, near Lesmahagow, Lanarkshire; and I have much pleasure in naming this and the preceding species in honour of the two distinguished French palæontologists, the founders of the genus.

Aulophyllum Wünschianum. Thomson. Sp. nov.

Plate IV., Fig. 7.

Specific Characters.—Corallum simple, short, turbinate, and much curved near its base. The calice is shallow, its margin is thin, and the central area is shallow and slightly raised above the inner ends of the primary septa. The epitheca is thin, and the outer ends of the primary septa are exposed as longitudinal ridges through the thin epitheca. The septa are of two orders. There are fifty-six primary, alternating with an equal number of secondary septa. The latter extends inwards from the periphery for half the length of the primary septa, and all are united by rectangular interseptal dissepiments, which are numerous in the outer zone and sparse in the intermediate ("interlocular") area. The primary septa are bilamellar for five-sixths of their length from their inner ends; in the outer peripheral zone they are single. There are ten interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ. The central area, as exposed in the transverse section, is ovate, and acuminate opposite the fossula. Its wall is composed of irregular lenticular convex plates, convexity pointing outwards, and united to the inner ends of the primary septa by the intervention of a system of angular plates; and around the inner margin of its periphery there is a cyclum of irregular and sparse septa. Some of these are more or less sinuous, and converge inwards to near the centre of the central area, and all are united by endothecal tissue of varied aspect and density. The fossula is small, and a septum, of half the length of the others, extends into it.

Height of corallum, 2 inches; diameter of section, 1 inch.

Formation, Carboniferous; Locality.—Found inbedded in the brecciated conglomerate that is interstratified between the red sandstone at the Cock of Arran—regarding the age of which several of the authors that have described the sections of the northern end of Arran are not agreed. Some regard the sandstone and conglomerate of the northern point, or Cock of Arran, as of old red sandstone age; whilst others have recorded it as of Permian age. The discovery of this coral, and a considerable number of other well-authenticated carboniferous fossils, establish beyond doubt that these rocks were deposited posterior to the deposition of the marine series of the carboniferous system. My own conviction is, that they are the equivalents of the millstone grit. Rocks of a similar colour and composition—and their superposition to the inferior marine series has a striking identity—are well exposed along the coast line to the south of Dunbar, Haddingtonshire. A detailed description of the sections, and a list of the fossils found, not only in the breccia, but also in some of the different horizons, with illustrations, will be published at no distant date. Meanwhile, I have the greatest pleasure in naming this species in honour of my old and valued friend, Edward A. Wünsch, F.G.S., who accompanied me when I made the discovery of the carboniferous fossils in the breccia, and also on many other occasions when investigating the north shore line of Arran. I have found this same species in the shale that overlies the lowest bed of limestone in Corrie Mines, Arran.

Aulophyllum impingeum. Thomson. Sp. nov.

Plate IV., Fig. 8.

Specific Characters.—Corallum simple, moderately tall, cylindrical, and curved. The epitheca is stout, and marked with encircling lines and shallow annulations of growth. The calice is wanting. The septa are delicate and numerous. There are sixty-eight primary, alternating with an equal number of secondary septa, and all are united by minute and rectangular interseptal dissepiments, which are dense in the outer zone and few in number in the intermediate ("interlocular") area. The central area is oblong, and its wall is formed by lenticular convex plates, convexity pointing inwards, and united to the inner ends of the primary septa by a system of large and angular plates. There is a cyclum of minute septa, which converge from the inner margin of the endotheca, and near their inner ends coalesce, and several of them impinge upon the tabulæ in the centre of the central area, and all are united by rectangular endothecal dissepiments, which are few in number. The fossula is short, and broad at its inner margin, and two of the primary septa, fully half the length of the others, extend into it.

Height of corallum (imperfect), 4 inches; diameter of section, 1 inch and 3 lines.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone in Petershill Quarry, near Bathgate, Linlithgowshire.

This species differs from all the other species of the genus by the form and arrangement of the columellarian area. The septa and the endothecal dissepiments are fewer in number, and several of the septa impinge upon the tabulæ in the centre of the central area.

Aulophyllum expansum. Thomson. Sp. nov.

Plate IV., Fig. 9.

Specific Characters.—Corallum simple, short, turbinate, and curved, and expands to an unusually broad calice. The epitheca is stout, and marked with encircling lines and irregular and shallow annulations of growth. The calice is broad and deep, and the central cup projects prominently above the inner ends of the primary septa. The septa are numerous, and bilamellar for three-fourths of their length from their inner ends, and around the outer area they are single and thin. There are nine interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ. There are sixty-two primary, alternating with an equal number of secondary septa. The latter extend inwards from the periphery for fully the half length of the primary septa, and all are united by rectangular interseptal dissepiments in the outer zone, and by angular dissepiments in the region of the inner ends of the secondary septa. In the intermediate ("interlocular") area they are few in number. The wall of the central area is composed of lenticular plates. Some of these are unusually large, and are united to the inner ends of the primary septa by a system of curved plates, which at their inner ends curve and fold round the endotheca. There is a cyclum of dense and minute dissepiments extending inwards from the wall for a line; they are then intercepted by a zone of vesicular tissue, which extends inwards to near the centre of the central area.

Height of corallum, 2 inches; diameter of calice, 1 inch 4 lines.

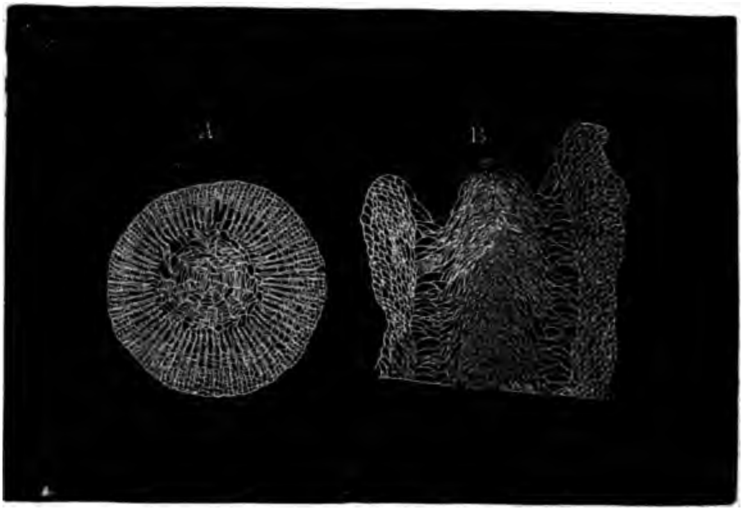
Formation, Carboniferous; Locality.—Found in a band of impure limestone, largely made up of corals, a few feet above the lowest bed of limestone in Charleston Quarry, Fifeshire.

This species differs from the preceding species by the form and arrangement of the central area. It is smaller in outline, and acuminate opposite the septal fossula, and the groove around the columella is broader, and, by the presence of the zone of reticulate tissue, which intercepts the inward extension of the minute septa, and the limited exposure of the tabulæ in the centre of the central area, may be regarded as a passage form between this genus and that of the genus *Cyclophyllum.*

Family Cyathophyllidia.

Genus *Clisiophyllum.* Dana.

Fig. 3.



Generic Characters.—Corallum simple, turbinate, or cono-cylindrical, and curved. The epitheca is of variable thickness, and marked with minute crenulate encircling lines and irregular annulations of growth. Calice variable in depth, and exhibits in the centre of its floor a conical boss. The surface of the boss presents a system of lamellæ, which in some forms are more or less spirally bent; whilst in others they are straight, and are attached to the inner ends of the primary septa by the intervention of a system of delicate curved dissepiments, and extend inwards and upwards to the median columellar crest on the crown of the boss, and each is united by intermellar dissepiments. The septa are well developed and of two orders. The primary septa never extend further inwards than near to the outer margin of the central boss, and in a transverse section exhibit laminæ for about three-fourths of their length from their inner ends, while towards the periphery they are single, thin, and more or less flexuous. The interlamellar space is occupied by minute transverse granular plates, in number from six to sixteen in the space of a line (Fig. 3A), which in a longitudinal section are seen to pass inwards and downwards along the inner face of the laminæ. The secondary septa are of variable length; in some forms they reach inwards fully a half of the length of the primary septa, whilst in others they are considerably shorter. They are united by interseptal dissepiments, which are few in number near the inner ends of the primary septa and more or less numerous in the external area, where they form a more or less dense vesicular tissue. The walls of the septa, the lamellæ, and the interseptal tissue, consist of two layers —the inner dense and granular, the outer, also granular, but much less dense. The fossula is variable in size in the different varieties, but usually well marked.

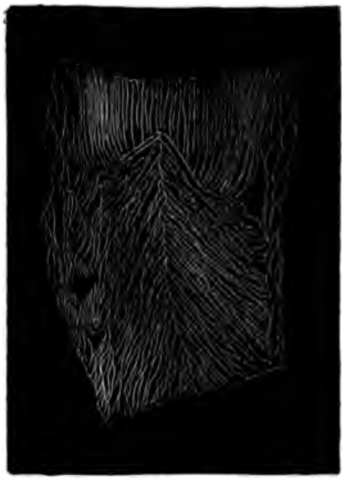
The longitudinal section (Fig. 3B) is triareal. The middle of the central area there is a median line which extends from the inferior to the superior extremity, and presents a crest on the crown of the conical boss in the centre of the calicular cavity. On each side of the median line there is a system of vesicular tabulæ, which are directed upwards and inwards to join in the columellarian line. Intermediate area ("interlocular space") is occupied by an outward extension of the tabulæ in large convex vesicles. External area ("interseptal space") is occupied by convex vesicular tissue, convexity pointing upwards and inwards, and arranged in oblique rows.

As regards the relationships of the genus *Clisiophyllum*, in the general features the external aspects present characters by which it may be readily distinguished from its near allies.

Professor James Dana's original definition of the genus

Clisiophyllum is as follows (*American Journal of Science*, vol. i., second edition):—

Fig. 4.



The accompanying figure is a *fac-simile* of the upper half of the original woodcut that accompanied Prof. Dana's paper.

"Transverse septa converging upward into an axial line. Quite simple, ramose or aggregato-glomerate. Corallum having the cells radiate; texture internally at middle consisting of septa and cellules converging upward, but without a distinct axis; texture exterior to this middle portion cellular."

This genus includes many of the so-called *Cyathophylla*, both simple and massive species. In internal structure they resemble the *Michelinieæ*, but differ in having the structure small; cellular exterior to the central convergent portion. The bottom of the cell has usually a pointed conical prominence, proceeding from the character of the septa within, and about this centre the lamellæ sometimes appear twisted. These species with twisted lamellæ may constitute in part the genus *Strombodes*, as this name is used by Phillip and Lonsdale. The name is from the Greek *κλῐσία*, (a tent), and alludes to the Λ-like figures which are made by the converging lamellæ about the centre, as seen in a vertical section." The distinguished author accompanies his description with two woodcuts.

The one represents *Clisiophyllum* proper, and exhibits structure similar to Pl. V., Fig. 5A; the other is from a massive asteroeid species.

From the above, the distinguished American palæontologist rests generic distinction upon (1) the conical boss in the centre of the calicular cavity; (2) the central lamellæ, which in some forms appear twisted; (3) the converging tissue, which in a longitudinal section is seen to pass into the central rod; (4) ramose forms, which he refers to the asteroeid species; (5) the septa extending into the central axis. Regarding the first of these characters, I have numerous specimens containing the conical boss in the centre of the calice (Pl. V., Fig. 1). As regards the second character, the central lamellæ are always present in the Scottish specimens, and of varied number and arrangement. I regard their number and arrangement as the special point of interest in specific diagnoses. As regards the third point, the interlamellar tissue is well exposed in longitudinal sections (Pl. V., Figs. 2A, 5A), and in Pl. VI., Figs. 1A, 2A, 3A, and 5A, from which it will be seen that the density of the endothecal tissue varies in proportion to the number and arrangement of the lamellæ of the central area. As to the fourth point, I am not aware of a compound or ramose variety having been discovered in British strata. There is, however, the genus *Lonsdalia* (M'Coy), in which a conical boss is always present in the centre of the calice, which, if in uncut specimens, might be grouped with the simple forms of *Clisiophyllum*. If, however, there is a transverse section made, the lamellæ are seen to pass from the inner ends of the primary septa, as in the latter; but in *Lonsdalia* the primary septa never extend to the periphery. They are intercepted by a zone of vesicular tissue, which is more or less dense, and gemmation is calicular, characters which have been regarded as of sufficient value to warrant generic distinction, and therefore cannot be included in the genus *Clisiophyllum*. As regards the fifth point, I have not discovered a single form belonging to this group in which the septa extends into the centre of the calicular cavity, and in all the forms that I have examined amongst the types of M. Edwards and J. Haime, in Paris, London, and Bristol, as also those in the Geological Survey Collection in Dublin, in no instance have I found the septa continuous from the periphery to the central axis. In some forms, however, if the specimen has not been sectioned transversely, it is possible that these eminent authors may have been misled, from the fact that the vesicular tissue that intersects the lamellæ is minute, and therefore the lamellæ approaches so close upon the inner ends of the primary septa that, unless the specimen is sectioned, it is all but impossible to detect the intersecting tissue—a fact that I was not aware of till I had made sections. It is, however, possible that ramose forms may be discovered; meanwhile, with our present knowledge, I cannot include compound forms in the genus *Clisiophyllum*.

Milne Edwards and J. Haime defined the genus *Clisiophyllum* (*Brit. Foss. Cor.*, *Introd.*, p. lxx., 1850) as follows:—"Corallum simple, turbinate. Septa well developed, and rising towards the centre of the calice, so as to form a spurious columella, but not twisted." Subsequently (*Pal. Foss. des Terr. Pal.*, p. 409) they extended their previous definition, whilst preserving its essential features, and, in particular, retaining the erroneous view that the sub-convolute laminæ of the central area are the inner ends of the primary septa, the species which they select as the type of the genus (viz., *Clis. Danaianum*) is stated to possess a large fossula,—a very unusual character in this genus.

Professor M'Coy (*Brit. Pal. Foss.*, p. 33, 1851) defined the genus *Clisiophyllum* as follows:—"Corallum simple, branched or aggregate, with vertical radiating lamellæ; a thin epitheca or outer wall; internal structure (vertical section) central area composed of small vesicular plates and cells, converging or arching upwards towards the centre, so as to form a conical boss in the cup; separation between these areas formed by an intermediate area of larger, nearly horizontal cellular structure; (horizontal section) a large central area of small, irregular, cellular texture, from which the primary lamellæ radiate to the outer walls; intermediate zone with few vesicular plates between the lamellæ; outer zone having the primary and secondary lamellæ connected by very numerous vesicular plates." It will thus be seen from the above, that M'Coy has represented most of the essential characters in the structure of *Clisiophyllum*. More especially has he the merit of clearly defining the triareal structure of the genus. The chief defects of his definition lie in his supposition that the ascending lamellæ of the central area are truly the septa, and in his not having detected the constant presence of a columellarian line in the centre, and repeating the opinion stated by Dana—viz., that the corallum was branched or aggregate.

Mr. Billings (*Can. Journal* for March, 1859) defined the genus as follows:—"The corals of this genus have the same general external form as those of the genus *Zaphrentis*, and their internal structure is also the same, except that the transverse diaphragms are elevated in the centre, so as to form a small conical protuberance in the bottom of the cup, and further, they are enveloped in an outer area composed of vesicular tissue. The septal fossette is small, and in worn specimens its place is often indicated by the prominence of one of the septa on the outside, which, being stronger than the others, forms a longitudinal angular ridge. The cells of the tissue which fills the outer area slope upwards and outwards."

The definition of the genus *Clisiophyllum* given by Prof. De Koninck (*Anim. Foss. Nouv. Recherches*, prem. partie, p. 39, 1872) is in most respects similar to that given by M. Edwards and J. Haime. The septa are described as extending to the centre of the calice; and the columellar plate is stated to be a prolongation of the principal septa.

A similar view of the structure of the genus is given by Dybowski (*Mon. der Zoanth. Scier. rug.*, p. 82, 1873). He, however, places *Clisiophyllum* in the neighbourhood of *Lithostrocion,* and defines it as having septa which closely embrace a freely projecting columellæ, and elevate themselves to form collectively an eminence in the centre of the calice.

The different definitions that have been recorded by these authors evidently have arisen from the fact that they have relied upon external aspects for their identification, and in some instances isolated forms have been described, and not unfrequently have both genera and species been described with no other warrant than merely apparently related external aspects; and in other instances characters have been assigned that have no bearing upon the structural characters upon which the genus *Clisiophyllum* was established. It is one thing to give a name to a species and quite another thing to investigate the structural details upon which either genera or species have been founded. If the essential character of a genus consists in the typical form of its representative, it becomes a scientific problem in palæontology to ascertain what are the structural features that determine their distinctive characters, and I hold that, to define a genus correctly, it is not sufficient to describe the mere outline of its representatives, but it is indispensible to point out the structural details which determine the particular genus and characteristics of the family under consideration. Now, if either of these authors had studied the structural details in properly-sectioned specimens, they might have recognised the true position of their forms in any proper system of classification. What is wanted is a detailed knowledge of the genus, a large number of sectioned specimens, and a knowledge of the sedimentary deposits they are found in. With such aids the definition becomes comparatively easy. Then we may become acquainted with many closely-allied species in either of the genera, leading by their near affinities to a clearer perception of their generic relations.

The genus *Clisiophyllum* is broadly separated from *Zaphrentis*, as defined by Billings, by the possession of a conical boss in the centre of the calice, a columellarian line extending from the inferior to the superior extremity of the corallum, and by the convex vesicular tissue that is seen in the broad columellarian area, and the intersection of the lamellæ of the central area from the inner ends of the primary septa; while in *Zaphrentis* the septa converge inwards, coalesce, and a portion extends into the centre of the calice, and fold round and form the walls of the fossula. From *Lithostrocian*, as defined by Dybowski—in the latter the columella intersects a complete system of rectangular tabulæ—and from the fact that the corallum is always compound, whilst it is simple in *Clisiophyllum*.

The genus *Clisiophyllum* is more or less related to the genera *Lonsdalia*, *Aspidiophyllum*, *Dibunophyllum*, *Rhodophyllum*, and *Cymatiophyllum*. From *Lonsdalia* (M'Coy) it is separated by the totally different arrangement of the septal system. In the latter they stop short, and are intersected from the periphery by a zone of vesicular tissue, which is more or less dense around the periphery, and is always compound, and gemmation is always produced by a rupture of the theca, at the lip of the calice, and is therefore more or less lateral; and thus the parent and the young coralet grow side by side, and therefore form compound masses. From *Aspidiophyllum* (Pl. VII., Fig. 7 and 7A), it is clearly separated. In the latter there is no median line extending from the inferior to the superior extremity of the corallum, and the centre of the corallum is occupied by more or less discontinuous vertical plates, which are united by more or less concave tabulæ, and the boss in the floor of the calice is always helmet-shaped. From *Dibunophyllum* (Pl. VII., Fig. 9), by the slightly raised boss in the centre of the calice, which is always divided in two by a mesial crest, which is variable in stoutness, by the discontinuous plates in the columellarian area, which are intersected by concave tabulæ. From *Rhodophyllum* (Pl. VII., Fig. 8). In the latter the boss in the centre of the calice is occupied by sub-convolute lamellæ, which fold round an imaginary axis, and present a dome-shaped aspect, and the totally different structure of the central area, which is formed of discontinuous lamellar plates, and these are intersected by slightly concave tabulæ, and the latter is usually of much larger dimensions; and from *Cymatiophyllum* (Pl. VII., Fig. 5), by the fact that the centre of the central area is more or less concave, and the lamellæ are sinuous, and frequently a portion of them extend across the centre of the columellarian area, and the sinuous discontinuous columellarian vertical plates in the central area, which are intersected by dense endothecal tissue. With these points of difference, they all resemble each other in the triareal arrangement of the structural details in the longitudinal section.

It will thus be seen, that the above marked characters of the central area are sufficiently distinct to warrant the separation of these forms into separate genera. As before stated, I am persuaded that it is only in the structural details of the central area that there is any classificatory value for either generic or specific distinction.

Clisiophyllum bipartitum. M'Coy.

Plate V., Fig. 1 and 1A.

Specific Characters.—Corallum simple, tall, cylindro-conical, and curved. The calice is deep, and exhibits in the centre of its floor a broad conical boss. The surface of the boss is marked with a system of lamellæ, which extend inwards from near the inner ends of the primary septa, and upwards to a median columellar crest in the crown of the boss. The epitheca is moderately stout, and marked with encircling lines and irregular and shallow annulations of growth. The septa are stout, and bilamellar for three-fourths of their length from their inner ends, and in the outer area they are single, thin, and flexuous. There are ten interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ. There are sixty-two primary, alternating with an equal number of secondary septa. The latter extend inwards for nearly three-fourths of the length of the primary, and all are united by rectangular interseptal dissepiments, which are numerous in the outer area and few in number in the intermediate ("interlocular") area. The central ("columellar") area is composed of thirty-six lamellæ, which are united to the inner ends of the primary septa by the intervention of a system of delicate plates, and a portion of them converge inwards to the median crest, whilst others stop short, and become united to the larger lamellæ, and all are united by rectangular interlamellar dissepiments. The median crest exhibits the cut ends of the inner series of the interlamellar dissepiments, which in a longitudinal section converge inwards, and become united in the centre of the central area, and form the columellarian line that extends from the inferior to the superior extremity of the corallum. The fossula is distinct, and two of the primary septa, of shorter length than the others, extend into it.

Height of corallum, 4 inches; diameter of calice, 1 inch 6 lines.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone in Broadstone Quarry, near Beith, Ayrshire.

Clisiophyllum Oblongum. Thomson. Sp. nov.

Plate V., Figs. 2 and 2A.

Specific Characters.—Corallum simple (imperfect), moderately tall, and cornute. The calice is wanting. The epitheca is stout, and marked with minute encircling striæ and irregular, deep, and broad annulations of growth (see outline of Fig. 2A). The septa are delicate and of two orders. There are sixty primary, and an equal number of secondary septa. The latter extend inwards from the periphery for a third of the length of the primary septa, and all are united by more or less rectangular interseptal dissepiments in the outer zone, and in the intermediate ("interlocular") area they are few in number. There are eight interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ, which in the longitudinal section (Fig. 2A) B are seen to converge inwards and downwards. The central area exhibits the cut ends of the vertical lamellæ, which are attached to the inner ends of the primary septa by a system of minute plates. There are seventeen lamellæ, and a portion of them extends inwards to the median crest, while a portion stop short and become united to the longer lamellæ, and all are united by rectangular interlamellar dissepiments. The central area in the transverse section is elliptical in outline. The longitudinal section is triareal. The central area is occupied by convex interlamellar dissepiments, convexity pointing outwards and upwards, and converge inwards to the median line, which extends from the inferior to the superior extremity of the conical boss in the centre of the calicular cavity. The intermediate ("interlocular") area is occupied by irregular convex plates or tabulæ, which are concealed where the section has passed downwards diagonally at the curved portions of the corallum, and exposes the interlamellar space, and thus exhibits the interlamellar striæ (Fig. 2A) B. The outer ("interseptal") area is composed of irregular convex cells, convexity pointing inwards and outwards, and arranged in oblique rows.

Height of corallum (imperfect), 3 inches; diameter of section at the long axis, 1 inch 4 lines; and at the narrow part, 1 inch 1 line.

Formation, Carboniferous; Locality.—Found in the band of shale that is superimposed on the lowest bed of limestone in Roughwood Quarry, near Beith, Ayrshire.

This species is distinguished by characters of a marked and distinct nature, the form and arrangement of the central area being oblong in outline, and the lamellæ few in number, and by the large convex interlamellar cells that are exhibited in the longitudinal section converging inwards to the mesial columellar line in the centre of the central area.

Clisiophyllum Danaianum. Thomson. Sp. nov

Plate V., Fig. 3.

Specific Characters.—Corallum simple, short, cylindro-conical, and slightly curved. The epitheca is stout, and there are minute and flexuous encircling lines and broad and irregular shallow annulations of growth. The calice is circular and deep, and everted around the periphery, and exhibits a conical boss in the centre of its floor. The surface of the boss is marked by a system of lamellar ridges, which converge inwards and upwards from near the inner ends of the primary septa to the mesial crest at its superior extremity. The septa are well developed and of two orders. The primary are bilamellar for four-fifths of their length from their inner ends. In the outer zone they are single, delicate, and flexuous. There are nine interlamellar plates in the space of a line. There are sixty-six primary, and an equal number of minute secondary septa, and all are united by interseptal dissepiments, which are minute and numerous around the inner margin of the periphery. They are less numerous and irregular in the central section of the interseptal spaces and few in number in the intermediate ("interlocular") area. The central area is obovate, and exhibits the cut ends of the vertical lamellæ. There are eighteen lamellæ. Some of them converge inwards, then coalesce, and a few of them extend inwards to the median crest in the centre of the central area, and all are united by interlamellar dissepiments, and the central area is united to the inner ends of the primary septa by the intervention of a system of delicate plates. The fossula is large, and three of the primary septa of shorter length than the others extend into it.

Height of corallum 4½ inches; diameter of calice, 1 inch and 1½ lines.

Formation, Carboniferous. *Locality.*—Found in the band of impure crystalline limestone that is exposed a few feet above the lowest bed of carboniferous limestone in Charleston Quarry, Fifeshire.

This grand species is so distinct in itself that it is quite superfluous in me to refer to its distinctive character; and I have great pleasure in naming it in honour of Prof. James Dana, LL.D., the distinguished American palæontologist, the founder of the genus.

Clisiophyllum M'Coyanum. Thomson.

Plate V., Figs. 4, 4a, and 4b.

Specific Characters.—Corallum simple, tall, cylindro-conical, and curved. The epitheca is stout, and marked with irregular encircling lines and shallow annulations of growth. The calice is sub-oblong and shallow, and everted around the periphery. There is a broad conical boss in the centre of its floor, and there are conspicuous lamellar ridges, which converge inwards and upwards from the inner ends of the primary septa to the median crest on the crown of the conical boss. The septa are stout, and bilamellar for three-fourths of their length from their inner ends, and single, thin, and flexuous in the outer zone. There are nine interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ. There are sixty primary septa in the section cut one inch below the calice, fifty-four in the section cut two inches below the calice, and fifty-two in the section cut an inch further down, and these alternate with an equal number of secondary septa. The latter extend inwards from the periphery for half the length of the others, and all are united by more or less rectangular interseptal dissepiments, which are numerous in the outer ("interseptal") zone and sparse in the intermediate ("interlocular") area. The central area is large and sub-elliptical, and exposes the cut ends of the vertical lamellæ. There are twenty-nine lamellæ in the upper and in the median section, and twenty-four in the lower section, and all are united by interlamellar dissepiments, and the outer margin of the boss is united to the inner ends of the primary septa, by a system of minute plates. The fossula is large in the upper, a little less in the median, and still smaller in the lowest section, and in all the three a primary septum, of shorter length than the others, extends into it.

Height of corallum, 4 inches; diameter of calice, 1 inch 4 lines at the narrowest, and 1 inch and 5 lines at the longest.

Formation, Carboniferous; Locality.—Found in a band of shale that is about three feet above the lowest bed of limestone in Gateside Quarry, near Beith, Ayrshire.

This species is distinguished from *Clis. bipartitum*, its nearest ally, by its sub-elliptical form. Its central area is not so broad, and the lamellæ are not so numerous, and the interseptal dissepiments are not so numerous, and its fossula is not so large.

This specimen has been cut into six different parts, and exposing the transverse sections from near the calice to within an inch of its lower extremity; and after a careful examination of all the sections, I am unable to determine characters sufficiently distinct to warrant any palæontologist, with even the most superficial knowledge of coralline remains, in defining more than one species—a result in keeping with my former observations in the different genera that has passed through my hands, and recorded in my previous communications to the Society.

Clisiophyllum Bowerbanki. Edwards and Haime.

Plate V., Figs 5 and 5A.

Specific Characters.—Corallum imperfect, simple, cylindroconical, and curved. The epitheca is stout, and marked with encircling lines and shallow annulations of growth. The calice is moderately deep and everted, and its floor is occupied by a prominent conical boss. The septa are delicate, and bilamellar for three-fourths of their length from their inner ends, and single and thin around the peripheral zone. There are ten interlamellar plates in the space of a line, which are the cut ends of the interlamellar granular striæ, which are seen in the longitudinal section to converge inwards and downwards at the curved part of the section, arising from the section being diagonal, and passing along the interlamellar space at the curved part of the corallum. There are sixty-six primary, alternating with an equal number of secondary septa, and the latter extend inwards from the periphery for a third of the length of the primary septa, and all are united by delicate interseptal dissepiments, which are numerous in the outer ("interseptal") zone and irregular and sparse in the intermediate ("interlocular") area. The central area is spherical, and exposes the cut ends of the vertical lamellæ, which are united to the inner ends of the primary septa by a system of angular plates. There are eighteen lamellar plates, and only one-half of them reaches the median crest in the centre of the conical boss, and all are united by numerous irregular interlamellar dissepiments. The longitudinal section is triareal. The central area is occupied by a system of convex vesicular cells, convexity pointing inwards and outwards, which at their inner ends meet those of the opposite half, and their union produces the median line, which extends from the base of the corallum to its superior extremity, and is seen in the crown of the conical boss in the centre of the calicular cavity. The intermediate ("interlocular") area exposes a system of convex tabulæ of large dimensions. The outer zone ("interseptal") area is occupied by a system of irregular convex cellular tissue, convexity pointing upwards and inwards, and arranged in oblique rows. The fossula is small, and one of the primary septa, half the length of the others, extends into it.

Height of corallum imperfect. A portion of the lower extremity is wanting. Diameter of calice, 1 inch 3 lines.

Formation, Carboniferous; Locality.—Found in a band of shale that overlies the lowest bed of limestone in Langside Quarry, near Beith, Ayrshire.

This species is distinguished from the preceding in the form and arrangement of the central area, it being spherical in outline. The lamellæ are less numerous, and only a half of their number extends into the median crest. A portion of the lamellæ is displaced by two curved bodies, which I take to be ampullas; they contain minute oval bodies, which I regard as ova. Whether I am correct in regarding these as ova is yet to be determined. This opinion I formerly recorded in the *Proceedings* of the Society, vol. ix., p. 153, and vol. xi., No. 1, p. 170, and since then I have discovered a number of specimens containing similar bodies, which I purpose investigating soon.

Clisiophyllum conoseptum. Keyserling.

Plate V., Fig. 6.

Specific Characters.—Corallum simple, stout, short, and cylindro-conical. The epitheca is stout, and marked with minute encircling lines and shallow annulations of growth. The calice is shallow and everted, and the centre is occupied by a boss, which is slightly raised above the inner ends of the primary septa, and exposes a system of lamellar ridges, which converge inwards and upwards from the inner ends of the primary septa to the long mesial crest in the crown of the boss. The septa are moderately stout and wide apart. The primary are bilamellar for three-fourths of their length from their inner ends. In the outer zone they are single, thin, and more or less flexuous. There are eight interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ. There are fifty-six primary septa, alternating with an equal number of minute secondary septa, and all are united by irregular and angular interseptal dissepiments, which are numerous around the inner margin of the periphery. Inwards they are sparse, and expose an irregular and open cellular tissue in the interseptal area. In the intermediate ("interlocular") zone they are few in number. The central area is orbicular, and exposes the cut ends of the lamellæ, which are more or less flexuous, and which converge inwards from the inner ends of the primary septa. A portion of them then unite, and the half of them extend into the mesial crest in the centre, and all are united by sparse and irregular interlamellar dissepiments. The fossula is large, and a primary septum, half the length of the others, extends into it.

Height of corallum, 3½ inches; diameter of section, 1 inch 7 lines.

Formation, Carboniferous; Locality.—Found in the coralline band of impure limestone that is interstratified with beds of arenacious shale, a few feet above the lowest bed of limestone in Charleston Quarry, Fifeshire. It is noteworthy that in this locality many of the specimens are considerably metamorphosed by the calcareous structure of the corallum being displaced by silica. This is usually found around the peripheral zone in many of the specimens, whilst in others the siliceous matter all but obscures the structural details throughout the corallum.

Clisiophyllum densiphyllum. Thomson. Sp. nov.

Plate V., Fig. 7.

Specific Characters.—Corallum (imperfect, a portion of both extremities is wanting) simple, tall, cylindro-conical, and curved. The epitheca is thin, and the outer ends of the septa are faintly exposed, and marked by encircling lines and broad, deep annulations of growth. The calice is wanting. A transverse section exhibits the sub-circular outline and the dense structural details of the corallum. The septa are numerous, and of two orders. The primary are bilamellar till they nearly reach the periphery, and around the inner margin of the periphery they are single and thin. There are four interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ. There are fifty-six primary, alternating with an equal number of secondary septa. The latter extend inwards from the periphery for a third of the length of the primary, and all are united by dense and more or less angular interseptal dissepiments in both the outer ("interseptal") and in the inner ("interlocular") zones. The central area is small and dense, and a transverse section exposes the cut ends of twenty-two lamellæ. These are the cut ends of the vertical lamellar plates, which are united to the inner ends of the primary septa by the intervention of a cyclum of angular plates. The lamellæ converge inwards from near the inner ends of the primary septa. Some of these unite into fascicles, and the central one extends into the median crest in the centre, and all are united by a system of interlamellar dissepiments. The median crest in the centre of the central area is the cut end of the columellar line, which extends from the inferior to the superior extremity of the corallum. The fossula is small and indistinct, and one of the primary septa, half the length of the others, extends into it.

Height of corallum, imperfect. The portion I have is 4 inches long, and the transverse section is 1 inch and 3½ lines broad.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone in Petershill Quarry, near Bathgate, Linlithgowshire.

This species differs greatly from all the other species of the genus by the dense structural details, by the small central area, and by the broad zone of endothecal plates that unite the lamellæ to the inner ends of the primary septa, and by the fact that the interlocular dissepiments are more numerous than is found in any other species that has come under my notice.

Clisiophyllum grandicum. Thomson. Sp. nov.

Plate V., Figs. 1 and 1A.

Specific Characters.—Simple, tall, cylindro-conical, and slightly curved, and a portion of the superior and of the lower extremity is wanting. The epitheca is stout, and marked with encircling lines and broad and shallow annulations of growth. The calice is wanting. The central area in the transverse section is small, and exposes the cut ends of eleven lamellæ. Some of these extend inwards from near the inner ends of the primary septa to the mesial crest, and are united at their outer ends to the inner extremities of the primary septa, and all are united by interlamellar dissepiments. The septa are delicate, and bilamellar for half their length from their inner ends, and flexuous and more or less vesicular in their outer zone. There are twenty-two interlamellar plates in the space of a line. There are eighty primary, alternating with an equal number of minute secondary septa, which are hardly recognisable in the dense vesicular tissue they intersect, and each are united by angular interseptal dissepiments, which are irregular and numerous in the outer ("interseptal") zone and sparse in the intermediate ("interlocular") area. The longitudinal section exhibits the triareal arrangement of the internal structure. In the centre of the central area there is a median line, which is curved near the upper extremity of the section, and on each side of the mesial line there is a system of convex plates, convexity pointing upwards and outwards, and those near the median line curve upwards at their inner ends, and rest upon the median ("columellarian") line. These are the cut margins of the interlamellar dissepiments. The intermediate ("interlocular") area is occupied by a system of irregular convex plates, convexity pointing upwards and more or less outwards. The outer ("interseptal") area is broad, and exposes the cut margins of the interseptal dissepiments. These are convex, convexity pointing upwards and inwards, and arranged in oblique rows. The fossula is moderate in size, and a primary septum, half the length of the others, extends into it, and a portion of the endothecal tissue passes into it.

Height of corallum (imperfect), length of specimen fully three inches; diameter of section, 1 inch 8 lines.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone in Langside Quarry, near Beith, Ayrshire.

This remarkable specimen is unique, and differs widely from all the other species that I have seen from the carboniferous rocks of Britain. For a long time I did regard it as *Clis. coniseptum* (Key), and recorded it as such in the Ann. and Mag. of Nat. Hist., ser. 4, vol. 17, Pl. 22, Figs. 3 and 3A; but, after a careful examination of the type specimen now in the Bristol Museum, I am satisfied that it has no specific relation to that species, and therefore must regard it as altogether new.

Clisiophyllum Broadstonianum. Thomson. Sp. nov.

Plate VI., Figs. 2 and 2A.

Specific Characters.—Corallum simple and moderately tall, conical, and curved. The epitheca is stout, and marked with coarse, irregular lines, and broad and shallow annulations of growth. The calice is imperfect in another specimen of the same species. The centre of the calice is occupied with a boss which is slightly raised above the inner ends of the primary septa. It is never so conical as the majority of the other species are, and is more elevated on the one side of the boss than it is on the other, and the median crest is elongated, and bends down into the depressed side of the boss opposite the fossula, and in a transverse section the lamellæ are seen to be somewhat irregular. There are twenty lamellæ which are united to the inner ends of the primary septa by the intervention of a system of minute plates. The lamellæ are more numerous on the elevated side of the central area than they are on the other, and they are united by interlamellar plates. The primary septa are bilamellar for three-fourths of their length from their inner ends. In the outer zone they are single and moderately flexuous. There are seven interlamellar plates in the space of a line, which, in a longitudinal section are seen as delicate striæ converging inwards and downwards, and each stria is laterally united by minute rectangular granular bars, presenting a minute fenestrated aspect. There are sixty primary, alternating with an equal number of delicate secondary septa, and all are united by minute interseptal dissepiments in the outer ("interseptal") area. These become sparse near the intermedial ("interlocular") area, and in the latter they are few in number. The longitudinal section is triareal. The centre of the central area is occupied by an irregular pseudo-median line, and on each side there is a zone of convex cells, convexity pointing outwards and upwards, and near the median line they are more numerous. The intermediate ("interlocular") area is occupied by a system of irregular convex cells, convexity pointing upwards and outwards. The outer ("interseptal") space exhibits the cut margins of the interseptal dissepiments; they are convex—convexity pointing upwards and inwards, and arranged in oblique rows. The outer zone of vesicular tissue is considerably narrower than those of its nearest allies. The fossula is small, and hardly recognisable. A primary septum, a third of the length of the others, extends into it.

Height of corallum, fully 2 inches; diameter of section, 1 inch and 1 line.

Formation, Carboniferous; Locality.—Found in a band of shale about three feet above the lowest bed of limestone in Broadstone Quarry, near Beith, Ayrshire.

This species may be said to be intermediate between *Clis. bipartitum* and that of *Clis. Bowerbanki.* It, however, differs from the former in the irregular arrangement of the lamellæ in the less conical boss, and there are a third less lamellæ. And from the latter it differs in the form and arrangement of the central area. The boss is broader, and it is never so much elevated in the centre of the calice. The lamellæ are more numerous, and are more regular, and the septa are a little stouter. It is noteworthy that I have not seen this variety from any other locality, and strictly confined to one horizon of strata, in Broadstone Quarry.

Clisiophyllum Genitzieanum. Thomson. Sp nov.

Plate VI., Figs. 3 and 3A.

Specific Characters.—Corallum simple, turbinate, and short. The epitheca is stout, and marked with delicate encircling lines and irregular and shallow annulations of growth. The calice is broad and shallow, and everted around the periphery; the boss in its centre is moderately raised above the inner ends of the primary septa, and is sub-oblong in outline, and the median crest is prominent, and the transverse section exposes the cut ends of twenty-one lamellæ. A portion of these converge and are attached to the median crest, and the others stop short and are united with the longer lamellæ, and each is attached to the inner ends of the primary septa by a system of angular plates, and all are united by rectangular interlamellar dissepiments. The septa are bilamellar for four-fifths of their length from their inner ends, and around the peripheral zone they are single and thin. There are eight interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ that are seen in a longitudinal section to converge inwards and downwards. There are fifty-eight primary, alternating with an equal number of secondary septa. The latter extend inwards for half the length of the primary, and all are united by irregular and angular interseptal dissepiments.

The longitudinal section is triareal. In the centre of the central area there is a median line, which extends from the inferior to the superior extremity of the corallum, and on either side of the columellarian line there are exposed a series of convex cells, convexity pointing upwards and outwards. The intermediate ("interlocular") area is composed of broad convex tabulæ, convexity pointing upwards and outwards. The outer ("interseptal") area is occupied by a system of convex cells, convexity pointing upwards and inwards, and arranged in oblique rows. The fossula is moderately large, and two of the primary septa, of shorter length than the others, extends into it.

Height of corallum, 1½ inches; diameter of calice, 1 inch 4 lines.

Formation, *Carboniferous*; *Locality*.—Found in a band of shale three feet above the lowest bed of limestone in Broadstone Quarry, near Beith, Ayrshire.

This species is closely allied to *Clis. M'Coyanum*. It, however, differs from it in the size and arrangement of the central area, which is of smaller dimensions, and the lamellæ are not so numerous, and the septa are never so stout; and it gives me great pleasure to name it in honour of Prof. Gintzie.

Clisiophyllum elegante. Thomson. Sp. nov.

Plate VI., Fig. 4.

Specific Characters.—Corallum simple, short, cylindro-conical, and curved. The epitheca is thin. The outer ends of the septa are visible through the thin wall. There are delicate encircling lines and shallow annulations of growth. The calice is deep, and thin around the lips, and the centre of its floor is occupied by a prominent conical boss, and the lamellar ridges converge upwards and inwards to the small median crest on the crown of the boss. The septa are delicate, and bilamellar to near the periphery. Then they are single. There are seven interlamellar plates in the space of a line. There are fifty-four primary, alternating with an equal number of secondary septa. The latter extend inwards for about half the length of the former, and all are united by more or less angular interseptal dissepiments, which are numerous in the outer zone, and sparse in the intermediate ("interlocular") area. The central area is seen in the transverse section to be broad in proportion to the total diameter of the corallum, and exhibits the cut ends of twenty-five lamellæ. One of the lamellæ extends from the mesial crest outwards, and into the septal fossula, and all are united to the inner ends of the primary septa by a system of angular plates, and the lamellæ are laterally united by interlamellar dissepiments. The fossula is small, and two of the primary septa, of shorter length than the others, extend into it.

Height of corallum, 2½ inches; diameter of calice, 1 inch.

Formation, Carboniferous; Locality.—Found in a band of shale that is about three feet above the lowest bed of limestone in Broadstone Quarry, near Beith, Ayrshire.

This elegant form is readily distinguished from any of the preceding species by its broad central area, and by the delicate and numerous lamellæ, and by the extension of one of the lamellæ from the median crest into the fossula, and by the prominent conical boss in the floor of the calice.

Cliophyllum abruptum. Thomson. Sp. nov.

Plate VI., Figs. 5 and 5A.

Specific Characters.--Corallum simple, tall, cylindro-conical, and curved. The epitheca is thick, and marked with stout irregular encircling lines and broad shallow annulations of growth. The calice is wanting. In another specimen it is seen to be shallow, and the boss in the centre is broad, and presents the form of a broad obtuse cone with an elongated median crest in its centre. The septa are short; some of them terminate abruptly about half the length of the others. There are seventy-eight primary, alternating with an equal number of delicate secondary septa, and each is united by rectangular interseptal dissepiments, which present a narrow dense zone around the periphery, rare and sparse in the intermediate ("interlocular") area. There are nine interlamellar plates in the space of a line, which are the cut ends of the interlamellar series, which in the longitudinal section are seen to converge inwards and downwards. The central area in the transverse section is broad, and occupies a half of the total diameter of the corallum, and exhibits the cut ends of the vertical lamellæ. These are irregular, and more or less flexuous. There are sixteen lamellar plates, and each is united by broad and close rectangular interlamellar dissepiments, and at their outer extremities are united to the inner ends of the primary septa by a zone of angular plates, and opposite to the abruptly terminated septa the lamellæ are short and irregular, and the endothecal tissue consists of large convex cells, convexity pointing outwards. The transverse section is sub-[illegible].

The longitudinal section is elliptical, and its centre is broad, and exposes the median line, which is formed by the union of the inner ends of the convex tabulæ, and its lateral margins are composed of the cut margins of the interlamellar dissepiments. They are convex in outline, convexity pointing outwards and upwards. The intermediate ("interlocular") area is occupied by a system of irregular plates, convexity pointing outwards and upwards, and at their inner ends they extend into the interlocular area. The outer ("interseptal") area is composed of a zone of irregular lenticular convex cells, convexity pointing inwards and upwards, and arranged in oblique rows. The septal fossula is small and obscure, and a septum of shorter length than the others, extends into it.

Height of corallum (imperfect), 4 inches; diameter of section, 1 inch 3 lines.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone in Gateside Quarry, near Beith.

This species is readily distinguished by its broad central area, and from the fact that the lamellæ are few in number and wide apart, by the totally different aspect of the endothecal tissue, and by the shorter septal system and the abrupt termination of a portion of the septa.

Clisiophyllum turbinatum. M'Coy.

Plate VI., Fig. 6.

Specific Characters.—Corallum simple, short, and turbinate. The epitheca is thin, and marked with delicate encircling lines and irregular and shallow annulations of growth. The calice is broad and moderately deep, and the centre of its floor is occupied by a boss which is slightly raised above the inner ends of the primary septa. The septa are moderately stout and bilamellar for three-thirds of their length from their inner ends, and single and thin around the inner margin of the periphery. . There are eight interlamellar plates in the space of a line. There are fifty primary, alternating with an equal number of secondary septa. The latter extend inwards for half the length of the former, and all are united by more or less angular interseptal dissepiments, which are numerous in the outer zone, and few in number in the intermediate ("interlocular") area. The transverse section exhibits the cut ends of the irregularly-disposed lamellæ, which are seen to converge inwards towards the median crest in the centre, and are united to the inner ends of the primary septa by the intervention of a system of angular plates, and all are united by more or less irregular interlamellar dissepiments. The septal fossula is moderately large, and a septum, half the length of the others, extends into its centre, and a septum on each side falls about a line short of the others.

Height of corallum, 1½ inch; diameter of calice, 1½ inch.

Formation, Carboniferous; Locality.—Found in the coralline band of shale about five feet above the lowest bed of limestone in the Poneil water at Brockley, near Lesmahagow, Lanarkshire.

This species can at all times be readily distinguished by its turbinate aspect, by its broad calice, and by the form and arrangement of its central area. It is not a common species in the carboniferous rocks of Scotland.

Clisiophyllum vesicularum. Thomson. Sp. nov.

Plate VI., Fig. 7.

Specific Characters.—Corallum simple, tall, and cylindro-conical. The epitheca is moderately stout, and marked with encircling lines and irregular shallow annulations of growth. The calice is moderately deep, and its centre is occupied by an oblong boss, which, near the apex, becomes acutely conical. The calice is contracted and thin around the lips. The septa are bilamellar for three-fourths of their length from their inner ends, and in the outer zone they are thin. There are ten interlamellar plates in the space of a line. There are sixty six primary, alternating with an equal number of secondary septa. The latter extend inwards from the periphery for four-fifths of the length of the primary septa, and they are united by more or less rectangular interseptal dissepiments, which extend inwards to the inner ends of the secondary septa, and in the intermediate ("interlocular") area they are all but wanting. The central area is elliptical in outline, and dense. There are forty-eight lamellæ, which, at their outer ends, are united to the inner ends of the primary septa by a system of angular plates, and converge inwards to the zone of vesicular tissue that occupies the centre of the central arc. This tissue occupies the place of the median crest, and in a longitudinal section would present a more or less dense vesicular rod in the centre, which has suggested the specific name, and the lamellæ are united by rectangular and dense interlamellar dissepiments. The fossula is small, and a primary septum, a little shorter than the others, extends into it.

Height of corallum (imperfect, a portion of the lower extremity is wanting). The specimen is 5 inches long; diameter of section at the long angle, 1 inch 10 lines; and 1 inch 6 lines at the narrowest.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone in Langside Quarry, Beith, Ayrshire.

This elegant species is distinguished from all the other species by its dense oblong central area, which is relatively small in proportion to the diameter of the corallum, and by the vesicular tissue in the centre of the central area and the numerous lamellæ of the central area.

Clisiophyllum intermedium. Thomson. Sp. nov.

Plate VI., Fig. 8.

Specific Characters.—Corallum simple, moderately tall, cylindro-conical, and curved. The epitheca is stout, and marked with large encircling lines and irregular and broad annulations of growth. The calice is shallow, and everted at its outer margin. The boss in the centre of its floor is slightly raised above the inner ends of the primary septa. The primary septa are short, and bilamellar for four-fifths of their length from their inner ends, and single and thin around the periphery. There are nine interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ, which in the longitudinal section are seen to converge inwards and downwards. There are sixty-six primary, alternating with an equal number of minute secondary septa, which are united by more or less angular interseptal dissepiments, numerous in the outer ("interseptal") area and few in number in the intermediate ("interlocular") zone. The central area is broad, and exposes the cut ends of twelve irregular lamellæ, which are more or less flexuous, and three of the lamellæ converge inwards, and become united to one end of the median crest on the one side, and on the other, one lamellæ extends inward, and is united to the opposite end of the median crest. The other lamellæ stop short of the centre, and are attached to the long lamellæ, and all are united by irregular and sparse interlamellar dissepiments. The fossula is small, and a primary septum, three-fourths of the length of the others, extends into it.

Height of corallum, 3½ inches; diameter of calice, 1 inch 4 lines.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone in Auchenskeoch Quarry, two miles south of Dalry, Ayrshire.

This species is readily distinguished from *Clis. abruptum*, its nearest ally, by the form and arrangement of the central area. It is sub-spherical in outline, and the lamellæ are irregular in their arrangement; while in *Clis. abruptum* the central area is oblong, and the lamellæ are not only more numerous, but are more symetrically arranged, and the septa extend further into the centre in the former than in the latter. Indeed, I have long hesitated whether this singular species should be grouped amongst *Clisiophylla*, or in that of the genus *Centreophyllum*. In the latter the lamellæ converges into the centre of the central area, where they more or less meet. In this species only four of the lamellæ converge into the small median crest, which, if cut longitudinally, would present a median line extending the entire length of the corallum. This being the distinguishing character of the genus *Clisiophyllum*, I feel justified in placing it in as an intermediate or passage form between these generæ.

Clisiophyllum Keyserlingi. M'Coy.

Plate VII., Fig. 1.

Specific Characters.—Corallum simple, tall, cylindro-conical, and curved. The epitheca is thick and marked with minute encircling lines and irregular and shallow annulations of growth. The calice is wanting. A transverse section exposes the cut ends of the vertical lamellæ, which are sub-convolute, and fold round and clasp the median crest in the centre of the central area. There are forty-four lamellæ, which are united to the inner ends of the primary septa by a system of angular plates, and all are united by numerous interlamellar dissepiments, and the median crest is subsinuous. The septa are of two orders. The primary septa are bilamellar for three-fourths of their length from their inner ends. In the outer zone they are single, thin, and more or less flexuous, and these alternate with a cyclum of secondary septa, which extend inwards for three-fourths of the length of the primary septa, and each is united by a dense zone of interseptal dissepiments in the outer area, and in the intermediate ("interlocular") zone they are few in number. There are ten interlamellar plates in the space of a line, which are the cut ends of the interlamellar striæ. There are seventy-four primary, alternating with an equal number of secondary septa. The fossula is small, and a septum, of shorter length than the others, extends into it.

Height of corallum (imperfect), 6½ inches; diameter of section, 2 inches and 1 line by 1 inch and ten lines.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone in the Auchenskeoch Quarry, two miles south of Dalry, Ayrshire.

Clisiophyllum subimbricatum. Thomson. Sp. nov.

Plate VII., Figs. 2, 2A, 2B, and 2C.

Specific Characters.—Corallum simple, moderately tall, conical, and curved. The epitheca is stout, with minute encircling lines and irregular annulations of growth. The calice is sub-elliptical in outline, and shallow. The conical boss in the centre of its floor is slightly raised above the inner ends of the primary septa, and two-thirds of the lamellæ fold round and clasp the median crest on its crown, and present a sub-overlapping aspect; while a portion of the lamellæ on the other side of the boss converge inwards in a more or less slanting direction to the median crest on the crown of the columella, and at their outer ends are attached to the inner ends of the primary septa by a system of angular plates, and all are united by irregular interlamellar dissepiments. The septa are bilamellar for three-fourths of their length from their inner ends. In the outer zone they are thin and more or less flexuous. There are seven interlamellar plates in the space of a line. There are fifty-six primary, alternating with an equal number of secondary septa, and all are united by rectangular interseptal dissepiments in the outer ("interseptal") zone and in the intermediate ("interlocular") area, which are remote and few in number. The fossula is moderately large, and two of the primary septa, of shorter length than the others, extend into it.

Height of corallum, 2¾ inches; diameter of section, 1 inch 3½ lines by 1 inch 1 line.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone in Broadstone Quarry, near Beith, Ayrshire.

This remarkable specimen is readily distinguished from *Clis. Keyserlingi*, its nearest ally, from the fact that it combines the characters of *Clisiophyllum* on the one side of the central area, where the lamellæ are seen to converge inwards, and more or less to fold round the median crest, and on the other side to *Rhodophyllum*, from the fact that the lamellæ are less regular, and present an imbricated aspect. They also fold round and clasp the central area (Figs. 2A, 2B, and 2C). All represent sections taken from different parts of the same corallum. The structural details of the central area are somewhat different, and might be regarded as belonging to different species; but, as stated in a former communication to the Society, *Proceed. Phil. Soc. of Glasgow,* vol. xi., No. 2, page 326—"In the great majority of cases the structural characters in the central area, in the earlier stages of growth, are usually the prototype of the mature corallum, unless in such cases as those where the growth has been interfered with, and in passage forms." This species, being one of the passage forms between the genus *Clisiophyllum* and that of *Rhodophyllum*, arising from some incident during the life of the polypi, which gave rise to the altered structural character, regarding which, with our present knowledge, I am unable to explain, unless by the doctrine of evolution. Meanwhile I deem it right to record all such peculiarities, in order that we may by-and-by arrive at a satisfactory explanation of structural details so much at variance.

Clisiophyllum irregulare. Thomson. Sp. nov.

Plate VII., Fig. 3.

Specific Characters.—Corallum simple, imperfect, conical, and curved. The epitheca is stout, and marked with encircling lines and shallow annulations of growth. The calice is wanting. In a transverse section the central area is broad, and elliptical in outline. The endothecal tissue is irregular. On one side three of the lamellæ are seen to converge inwards to the median crest, while in the other portion of the central area the endothecal tissue is irregular, and presents a confused mass. The septa are of two orders. The primary are bilamellar for four-fifths of their length from their inner ends. In the outer zone they are single and thin. There are ten interlamellar plates in the space of a line, which in the longitudinal section are seen to converge inwards and downwards. There are sixty-two primary, alternating with an equal number of secondary septa. The latter extend inwards from the periphery for two-thirds of the length of the primary, and all are united by a broad zone of interseptal dissepiments in the outer ("interseptal") area, and in the intermediate ("interlocular") area they are few and remote, and a portion of the endothecal tissue extends into the interlocular area. The fossula is small, and two primary septa, of shorter length than the others, extend into it.

Height of corallum, imperfect. The calice and a portion of the lower extremity is wanting. The specimen is 2 inches long and 1 inch 7 lines broad at the superior extremity.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone in Broadstone Quarry, near Beith, Ayshire.

This remarkable species differs so much from all the other species of the genus that it can at all times be distinguished by characters of an unusually distinct nature. Indeed, previous to making a longitudinal section, I was disposed to place it amongst the passage forms of the genus *Rhodophyllum.* But the longitudinal section exposes the median line, extending from the inferior to the superior extremity of the corallum, the distinguishing character of the genus *Clisiophyllum.* It is noteworthy that I have found this remarkable variety of the genus in no other locality in Scotland than in Broadstone and Gateside, which is contiguous.

Clisiophyllum subplicatum. Thomson. Sp. nov.

Plate VII., Figs. 4 and 4A.

Specific Characters.—Corallum simple, moderately tall, conical and curved. The epitheca is thin, and the outer ends of the septa are exposed through the delicate covering, and is marked with minute crenulate encircling lines and irregular shallow annulations of growth. The calice is deep and thin around the periphery, and the centre of its floor is occupied by a broad conical boss, and the lamellæ are exposed plicating around the anterior half; while those on the half on the dorsal face converge inwards and upwards to the median crest, presenting characters which belong to the species *Keyserlingi*, *bipartitum*, and *imbricatum.* The septa are bilamellar for two-thirds of their length from their inner ends, and thin and single in the outer zone. There are eleven interlamellar plates in the space of a line, which in the longitudinal section are seen to converge inwards and downwards between the laminæ of each septum. There are fifty-eight primary, alternating with an equal number of secondary septa, and all are united by rectangular interseptal dissepiments in the outer ("interseptal") zone, which in the intermediate ("interlocular") area are few and wide apart.

The longitudinal section is triareal. The central area exposes the columellar line, extending from the inferior to the superior extremity of the corallum, and the broad zone of convex endothecal tissue, convexity pointing upwards and outwards. The intermediate ("interlocular") area is occupied by irregular tabulæ; and the outer ("interseptal") area is composed of convex interseptal dissepiments, convexity pointing inwards and upwards, and arranged in oblique rows. The septal fossula is moderately large, and a primary septum, of shorter length than the others, extends into it.

Height of corallum, 2 inches 10 lines; diameter, 1 inch 4 lines.

Formation, Carboniferous; Locality.—Found in the band of shale that overlies the lowest bed of limestone in Broadstone Quarry, near Beith, Ayrshire.

This remarkable species is distinguished by characters of an unusually marked kind. In the central area there are exposed the lamellæ of *Cy. bipartitum* in one portion, in another the lamellæ of *Cy. Keyserlingi*, while on the larger proportion of the central area the lamellæ are not so regular. They more or less plicate over each other, the latter characteristic largely predominating, suggested the specific name.

Clisiophyllum centrocellulosum. Thomson. Sp. nov.

Plate VII., Fig. 6.

Specific Characters.—Corallum simple, tall, cylindro-conical, and curved. The epitheca is stout, and marked with delicate encircling lines and irregular annulations of growth. The calice is moderately deep and thin around the lips, and the centre of its floor is occupied by a conical boss, with a broad elongated apex. The septa are long and moderately stout. There are sixty-four primary, alternating with an equal number of secondary septa; the latter extends inwards from the periphery for half the length of the primary, and all are united by a broad zone of interseptal dissepiments. In the outer ("interseptal") zone and in the intermediate ("interlocular") area they are few in number and wide apart. The primary septa are bilamellar for four-fifths of their length from their inner ends. In the outer zone they are single and thin. There are six interlamellar plates in the space of a line. A transverse section exposes the cut ends of twenty-two lamellæ, which are united to the inner ends of the primary septa by the intervention of a system of angular plates, and each is united by rectangular interlamellar dissepiments, and the centre of the central area is occupied by a group of convex cells, convexity pointing outwards, and which are the cut ends of the cellular tissue that forms the broad apex of the crown of the conical boss, and may be regarded as a passage form between *Clisiophyllum* and that of *Aspidiophyllum.* The septal fossula is small, and a septum, of shorter length than the others, extends into it.

Height of corallum, 4¾ inches ; diameter of calice, 1 inch 7 lines.

Formation, Carboniferous ; Locality.—Found in the band of shale that is three feet above the lowest bed of limestone in Gateside Quarry, near Beith, Ayrshire.

This species is characterised by the broad crest on the crown of the conical boss, and by the cellular tissue in the centre of the central area, as seen in transverse section, and by the central area being proportionately smaller than it is in *Clis. Geinitz,* its nearest ally, and its more cylindrical form.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1.—*Cyclophyllum,* a restoration of what I conceive was the external aspect of the polyp when in life, showing the double circlet of tentacles on the superior extremity of the corallum.

PLATE II.

Fig. 1.—*Cyclophyllum fungites* (Ure), represents the external aspect of the original coral figured in "The History of Rutherglen and East Kilbride," page 317, plate 20, fig. 6, 1793; taken from a photograph before the specimen was cut.

,, 1A.—A transverse section of the same, natural size, exposing the structure of the corallum at the part where the transverse line is represented in fig. 1.

,, 1B.—A longitudinal section of the same, natural size. The letter B points to a small portion of the interlamellar striæ exposed where the corallum was curved. In cutting the longitudinal section at the curved part, the section passes diagonally between the lamellæ of the septa, and thus exposes the stria. Lower carboniferous, Shields, East Kilbride, Lanarkshire (?)

,, 3.—*Cyclophyllum Ureianum,* Thomson, Sp. nov., showing in outline the superior extremity of the corallum, and the double cup in the centre of the calicular cavity, and the structural details of the cylindrical columella.

,, 3A.—A transverse section of the same, natural size, exposing a transverse section of the structural details of the central area. Lower carboniferous, Petershill Quarry, Bathgate, Linlithgowshire.

,, 4.—Represents a weathered specimen, showing the tubular columellæ and the internal structure, and how a portion of the plates of the intermediate ("interlocular") area extend, and fold round and clasp the wall of the tubular columella. Lower carboniferous, Cunningham, Bedland Quarry, near Dalry, Ayrshire.

Fig. 5.—*Cyclophyllum Bowerbanki*, Edwards and Haime. A transverse section. showing the arrangement of the dense endothecal structure and how the wall is attached to the inner ends of the primary septa.

" 5A.—A longitudinal section of the same. This specimen was much curved, consequently the section is cut more or less diagonally, and thus exposes the interlamellar stria of the septa at B. Lower carboniferous, Gameshill Quarry, near Dunlop, Ayrshire.

" 6.—*Cyclophyllum biacuminatum*, Thomson, a transverse section, natural size. Lower carboniferous, Roughwood, Beith, Ayrshire.

" 7.—*Cyclophyllum pachyendothecum*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.

" 8.—*Cyclophyllum obovatum*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Trearn, Beith, Ayrshire.

" 9.—*Cyclophyllum Scoulerianum*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.

" 10.—*Cyclophyllum Duncanianum*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.

" 11.—*Cyclophyllum ellipticum*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Roughwood, Beith, Ayrshire.

" 12.—*Cyclophyllum orbiculum*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Trearn, Beith, Ayrshire.

PLATE III.

Fig. 1.—*Cyclophyllum Carpenterianum*, Thomson, sp. nov., a longitudinal section, natural size, exposing the structural details of the broad tubular columella and interlamellar striæ.

" 1A.—A transverse section of the same, natural size. Lower carboniferous, Poneil Water, Brockley, Lesmahagow, Lanarkshire.

" 2.—*Cyclophyllum Bennieianum*, Thomson, sp. nov., showing the external aspect and the double cup at the superior extremity of the corallum.

" 2A, 2B, and 2C.—Are transverse sections of the same. This specimen is cut at six different parts of the corallum. The sections here represented are from the parts indicated by the transverse lines, in order to show that in a distinct and normal corallum the structural details are constant and persistent throughout.

" 3.—*Cyclophyllum M'Kendrickianum*, Thomson, sp. nov., a transverse section, natural size. In this section is represented a foreign body that has got embedded into the interlocular area and has arrested temporarily the secretion of the sclerodermic matter above, and below this section the septal system is in no way interfered with. Lower carboniferous, Petershill Quarry, Bathgate, Linlithgowshire.

Fig. 4.—*Cyclophyllum curvilineare*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Petershill Quarry, Bathgate, Linlithgowshire.

„ 5.—*Cyclophyllum concentricum*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Gameshill, Dunlop, Ayrshire.

„ 6.—*Cyclophyllum cylindricum*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Petershill, Bathgate, Linlithgowshire.

„ 7.—*Cyclophyllum frondicum*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Catscraig, Dunbar, Haddingtonshire.

„ 8.—*Cyclophyllum tortuosum*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Petershill, Bathgate, Linlithgowshire.

„ 9.—*Cyclophyllum paradoxacum*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.

„ 10.—*Cyclophyllum intermedium*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Nettlehurst, Beith, Ayrshire.

„ 11.—*Cyclophyllum radianum*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Petershill, Bathgate, Linlithgowshire.

„ 12.—*Cyclophyllum Moseleyianum*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Trearn, Beith, Ayrshire.

„ 13.—*Cyclophyllum vesicularum*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Petershill, Bathgate, Linlithgowshire.

Plate IV.

Fig. 1.—*Aulophyllum Patrickianum*, Thomson, sp. nov., a transverse section, natural size, showing the length of the lamellæ, extending over the superior face of the tabulæ to near the centre of the central area.

„ 1a.—A longitudinal section of the same natural size, exhibiting the broad tabulæ in the central area, which are seen very much broader than is exposed in the transverse section, and which suggested to me that the lamellæ did not intersect the tabulæ, but rested upon their superior faces. Lower carboniferous, Langside, Beith, Ayrshire.

„ 2.—*Aulophyllum fungites*, Edwards and Haime, a transverse section, natural size, showing the superior extremity of the tabulæ, the minute lamella, and how these are united to the inner end of the primary septa by a system of convex plates. Lower carboniferous, Petershill, Bathgate, Linlithgowshire.

„ 3.—*Aulophyllum Edwardsianum*, Duncan and Thomson, a transverse section, natural size. Lower carboniferous, Brockley, Lesmahagow, Lanarkshire.

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Fig. 4B.—Another transverse section of the same, natural size. This species has been cut into six different sections—4 represents the structure one inch from the superior extremity of the corallum; 4A is taken from two inches from the calice; and 4B represents the structural details three inches from the calice, and one inch from the lower extremity of the corallum.

,, 5.—*Clisiophyllum Bowerbanki*, Edwards and Haime, a transverse section, natural size, the dark spaces are elongated cells, with a distinct double wall, enclosing minute ovular bodies.

,, 5A.—A longitudinal section of the same, natural size, showing the form and arrangement of the calice with the conical boss in the centre. The median line and the vesicular convex tissue on either side. Langside, Beith, Ayrshire.

,, 6.—*Clisiophyllum conoseptum*, Keys, a transverse section, natural size. Lower carboniferous, Charleston, Fifeshire.

,, 7.—*Clisiophyllum densiphyllum*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Petershill, Bathgate, Linlithgowshire.

PLATE VI.

Fig. 1.—*Clisiophyllum grandicum*, Thomson, sp. nov., a transverse section, natural size.

,, 1A.—A longitudinal section of the same, natural size, exposing the median line and the narrow zone of convex plates on either side. This corallum is twisted near the upper part of the specimen. Lower carboniferous, Langside, Beith, Ayrshire.

,, 2.—*Clisiophyllum Broadstoneianum*, Thomson, sp. nov., a transverse section, natural size.

,, 2A.—A longitudinal section of the same, natural size, showing the irregular median line and dense convex tissue on either side. This species is found more abundant in this locality than in any other locality that I have yet visited. Lower carboniferous, Broadstone, Beith, Ayrshire.

,, 3.—*Clisiophyllum Genitzianum*, Thomson, sp. nov., a transverse section, natural size, exhibiting a small group of ovuler bodies on one side of the central area.

,, 3A.—A longitudinal section of the same, natural size, exposing the median line and the interlammellar stria. Lower carboniferous, Broadstone, Beith, Ayrshire.

,, 4.—*Clisiophyllum elegante*, Thomson, sp. nov., a transverse section, natural size. Lower carboniferous, Broadstone, Beith, Ayrshire.

,, 5.—*Clisiophyllum abruptum*, Thomson, sp. nov., a transverse section, showing the abrupt termination of a number of the septa, the broad central area, and the cut ends of the sparse lamella.

,, 5A.—A longitudinal section of the same, natural size, showing the dense vesicular tissue in either side of the median line. Lower carboniferous, Gateside, Beith, Ayrshire.

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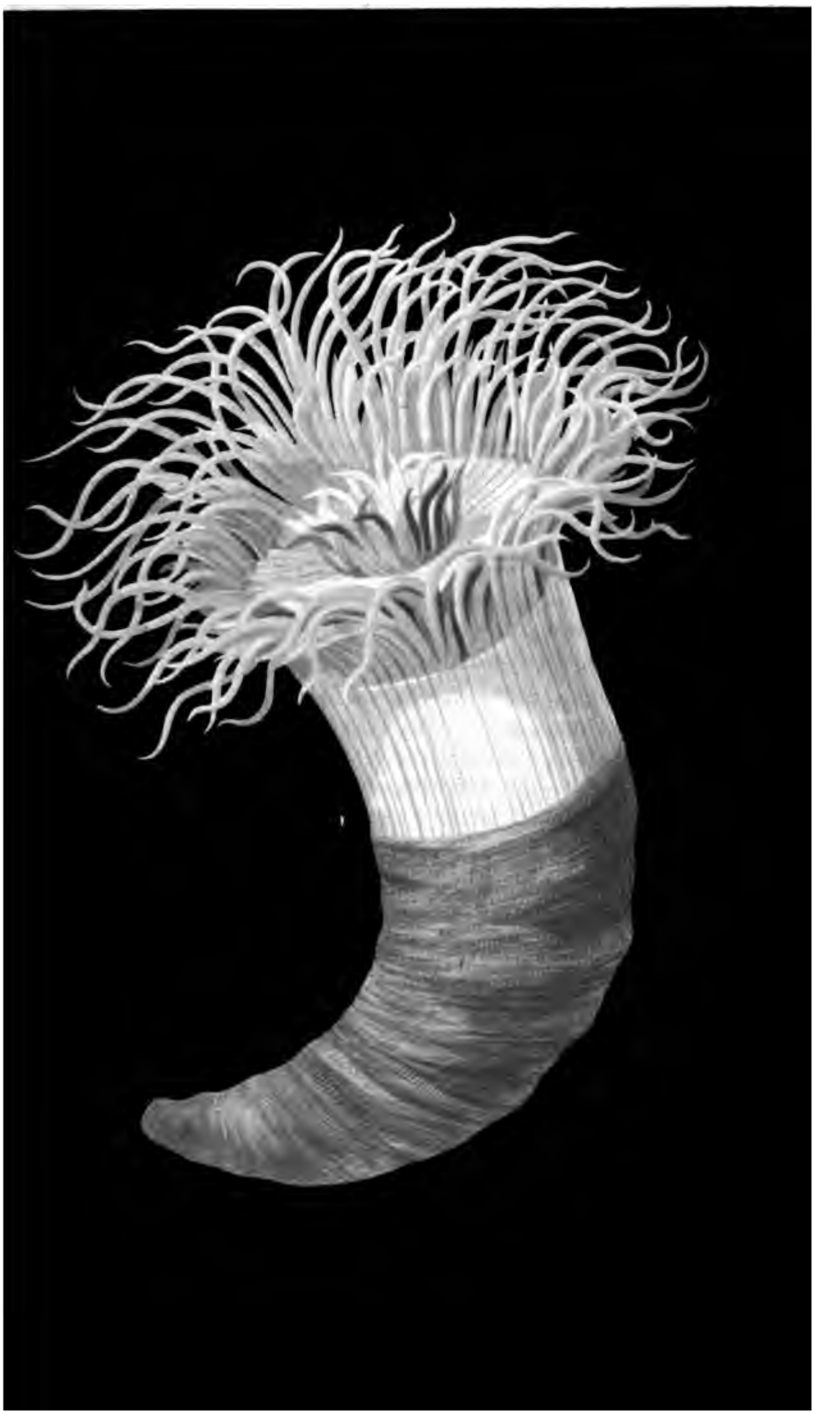

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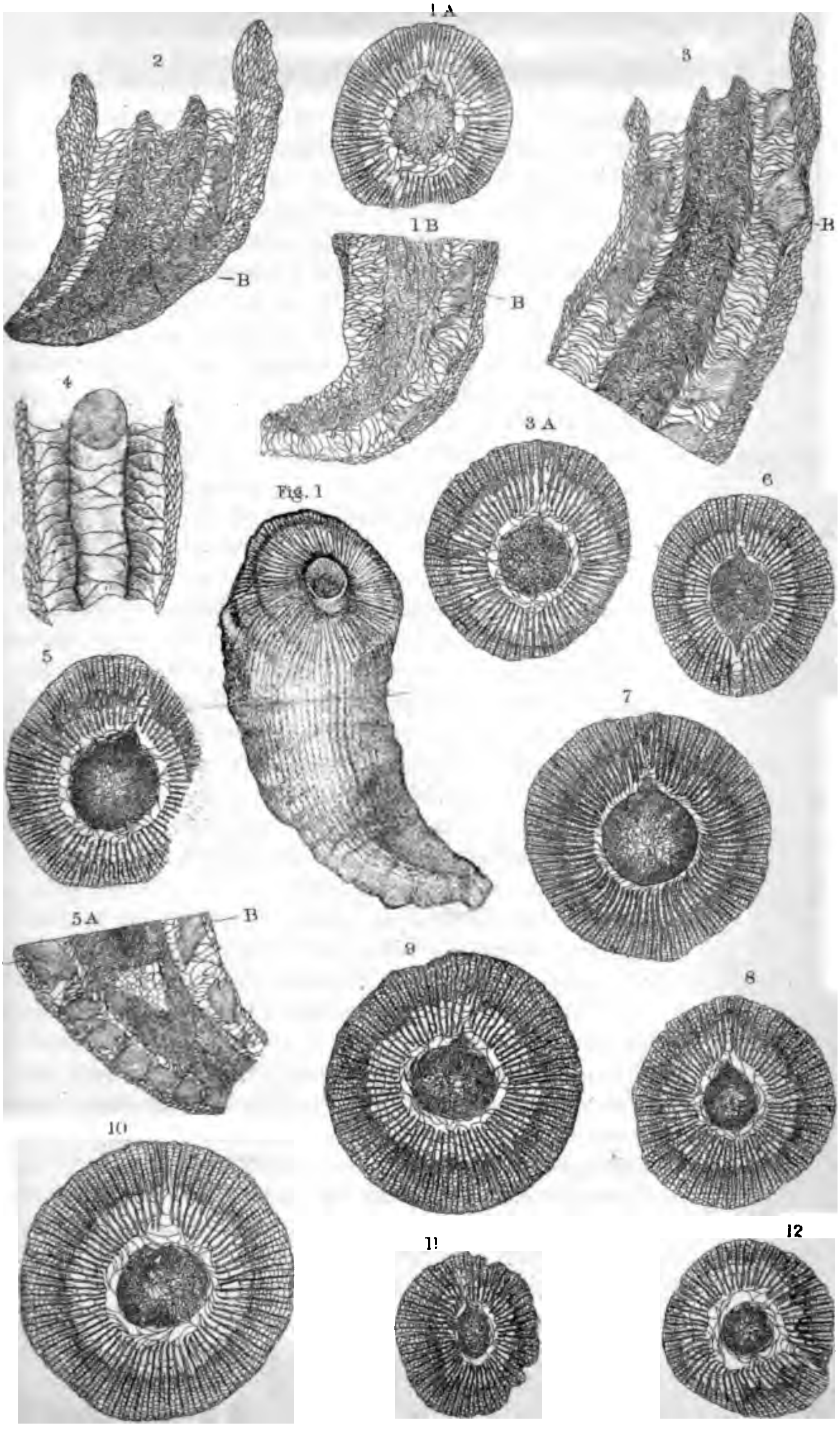
Proceedings Phil. Soc. of Glasgow. Plate II.



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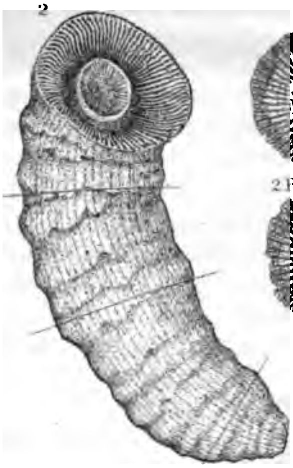

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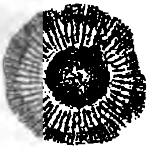

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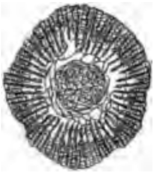

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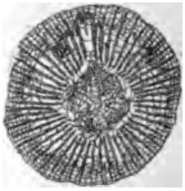

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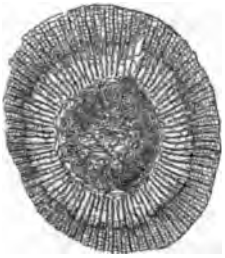
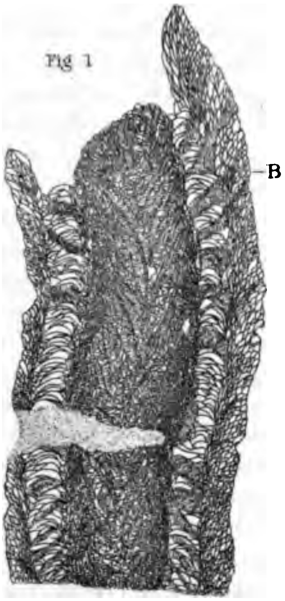


Fig. 1



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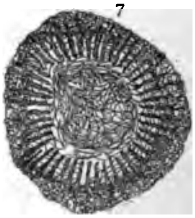

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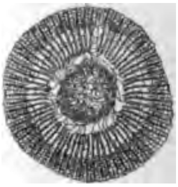

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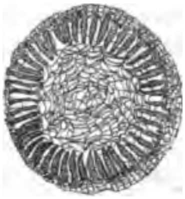

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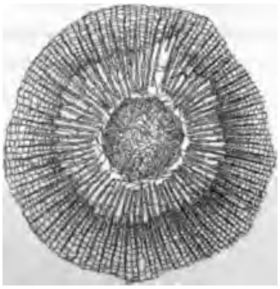

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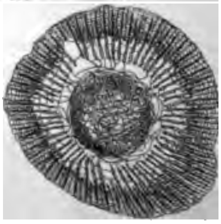

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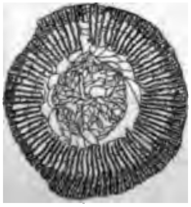

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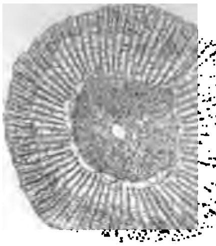

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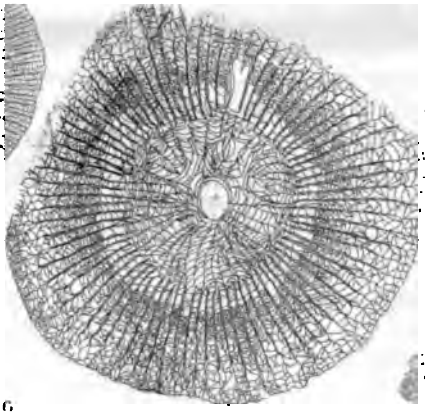

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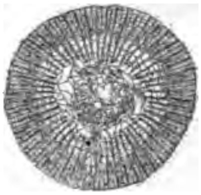

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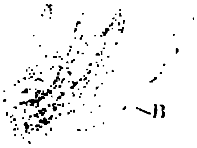

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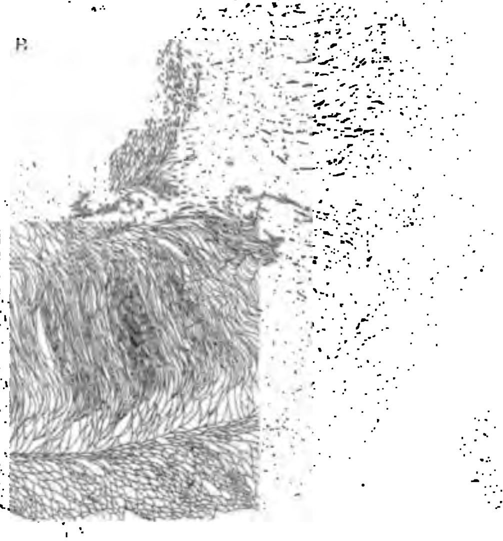

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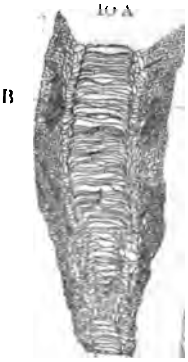

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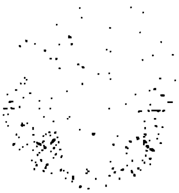

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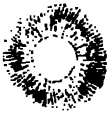

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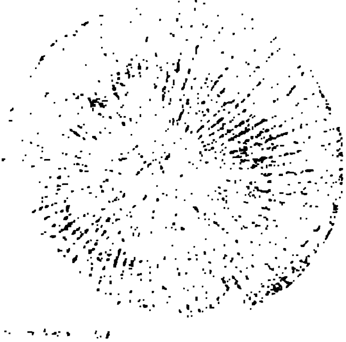

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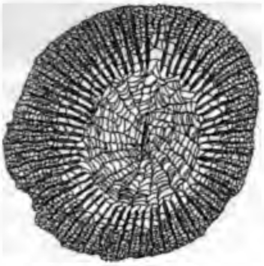

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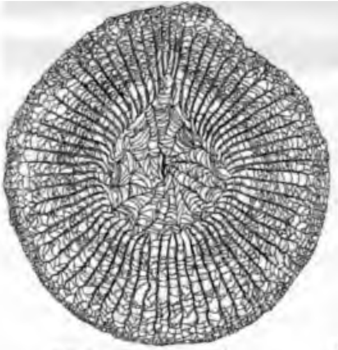

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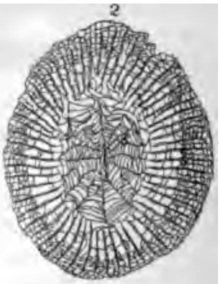

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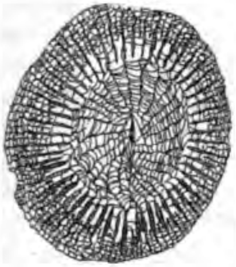

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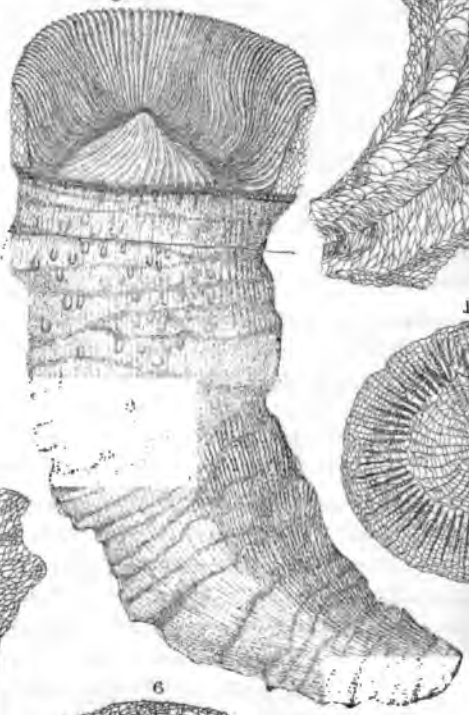

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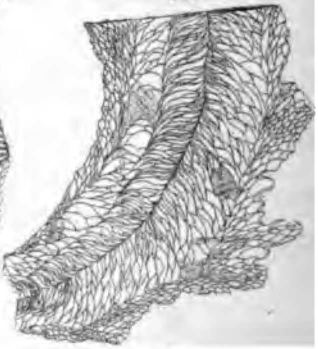

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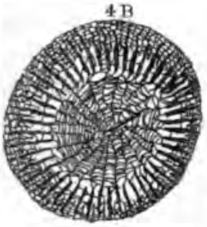

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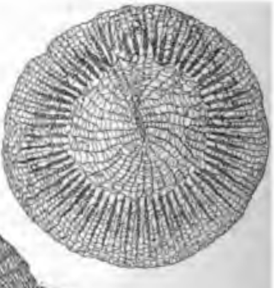

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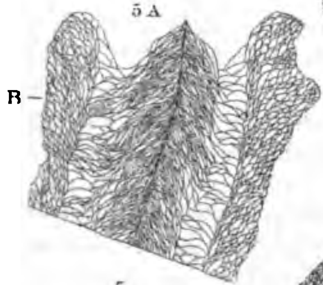

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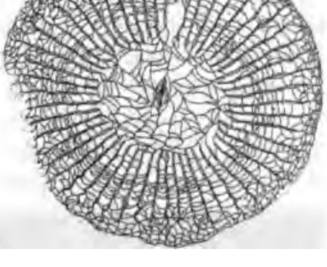

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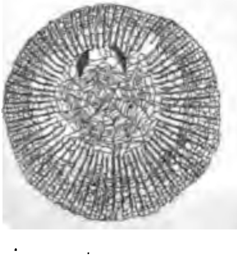

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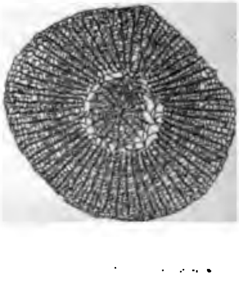

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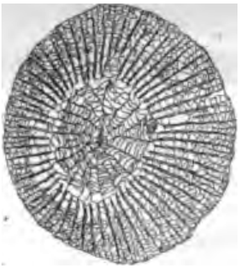

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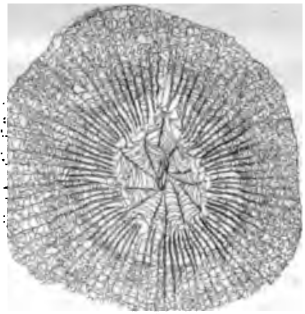

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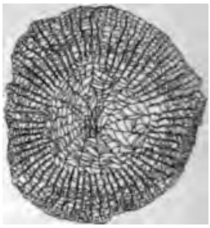

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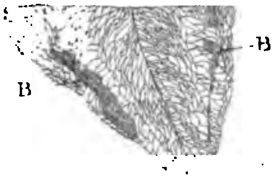

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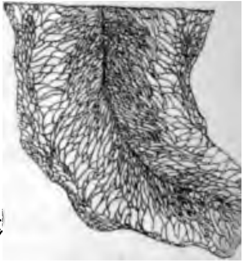

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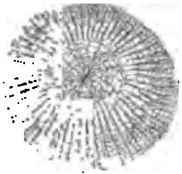

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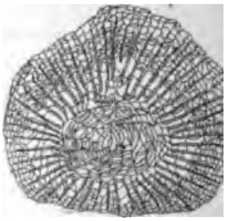

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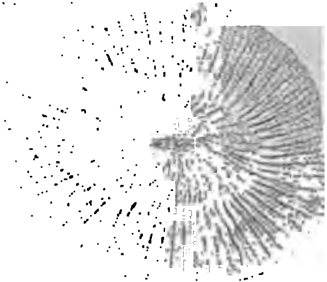

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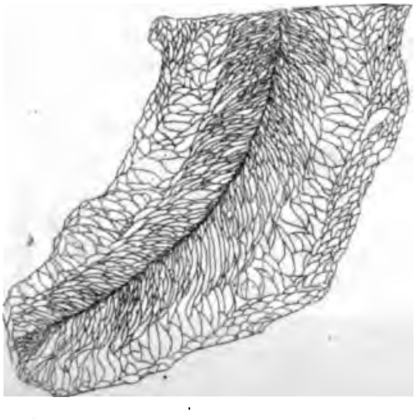

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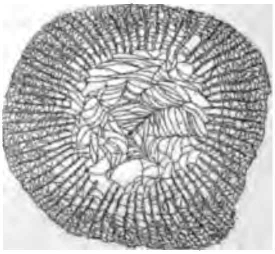

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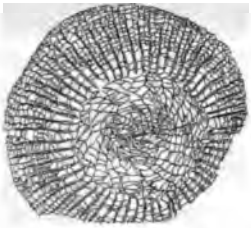

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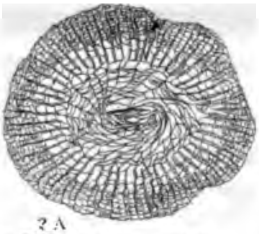

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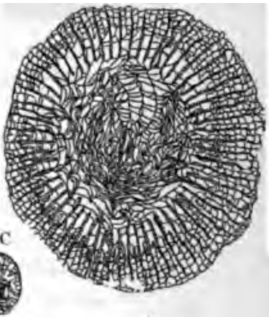

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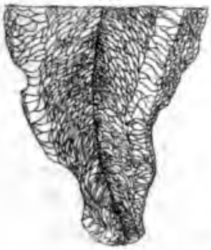

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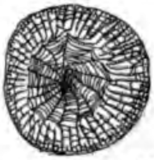

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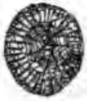

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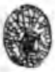

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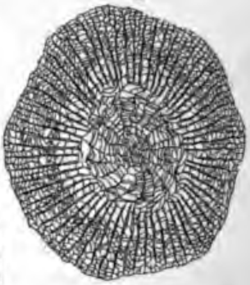

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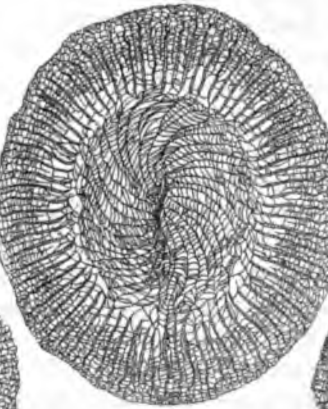

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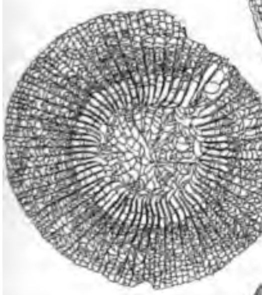

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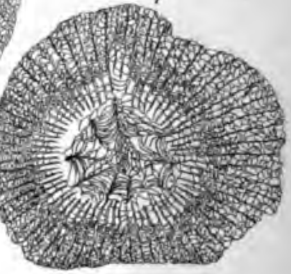

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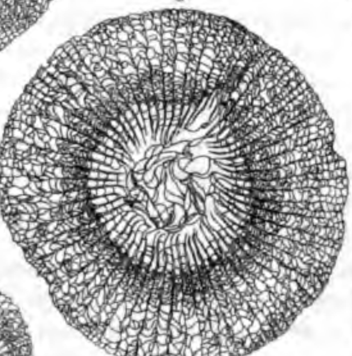

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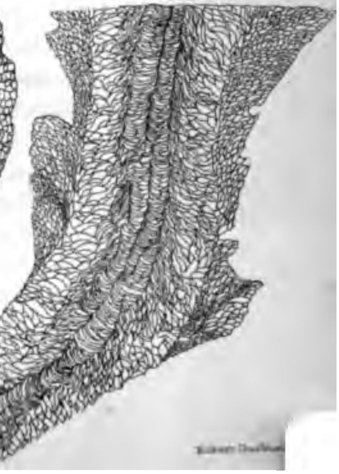

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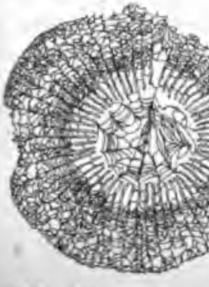

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facsimiles of the structural details of the interesting group to which that species belongs.

To Professor James Dana, LL.D., Yale College, Newhaven, C.S., America, my thanks are specially due, for the important aid his original paper on the genus *Clisiophyllum* afforded me.

For the important aid in being allowed to examine the types of several of the species, I desire to express my full acknowledgments to Professor Edwards, of Paris; to Professor L. G. de Köninck, of Liège, Belgium; to Robert Etheridge, Sen., Esq., F.R.S., London; to W. H. Bailey, Esq., F.G.S., Dublin; to Edward Tawney, Esq., F.G.S. (then Curator of the Museum, Bristol, now of the Woodwardian Collection, Cambridge). To Robert Craige, Esq., Langside, Beith, for much valuable assistance in collecting a number of the specimens and important information regarding the stratigraphical position of many of the species, my special thanks are due; and to Mr. James Bennie, of the Geological Survey Staff of Scotland, I wish to express my thanks for aiding me in discovering what I believe is the locality where the Rev. David Ure discovered his coral.

And I wish further to say, that if the results have been long of being issued, the delay arose from a desire to make my inquiry as complete as it was possible for me to do, prompted from a knowledge of the diversity of opinions fully expressed in the works of Milne-Edwards and Julius Haime and that of Professor M'Coy. I wish to add, that I might have added a great many more of the varieties of the genera of *Clisiophyllum* and *Cyclophyllum*, but I hope that what is illustrated and described will be accepted as of sufficient value in warranting me in issuing the present communication.

In conclusion, I beg to state that in no instance have I introduced a new species unless I possessed duplicates of such, and in all cases I have given the localities only for those species discovered. By-and-by, when my investigations will warrant, and the specimens from each of the other localities have been sectioned, I hope to prepare a more detailed and extended list of the forms found in each of the localities.

XIV.—*The Works of the late Charles Wilson, Esq.: born 19th June, 1810, died 6th February, 1863.* By David Thomson, Esq., I.A., F.R.I.B.A.

[Read before the Architectural Section, 13th March, 1882.]

With your leave, I purpose bringing before you this evening a short account of the principal works executed by the late Mr. Wilson, and will endeavour to do so in a somewhat chronological order, as we may thereby be enabled to trace, in some measure, the progress and development of his taste, genius, and characteristics, and mark the influences which were at work, moulding, changing, and enlarging the public taste during the interesting and eventful period embraced between the years 1830 and 1860.

Mr. Wilson had the great good fortune of being trained to the profession in the office of David Hamilton, an architect of surpassing abilities, great reputation, and in extensive practice ; and from the first he was brought into contact with a mind dignified and expansive, enriched by the study of architecture as developed under the enobling influence of classic art, and skilled in a high degree in all the best principles and traditions of the builders' craft. Mr. Wilson was the son of a builder, and was engaged in assisting his father in the business for some year or two before he entered Mr. Hamilton's office, and we suppose the knowledge acquired with his father was of service to him in the way of preparing him to absorb and assimilate more readily the lessons revealed to him through his office work ; certain it is that he soon became a favourite pupil, and in a few years was promoted to the chief seat in the office. In this position he had ample opportunity afforded him of becoming intimately acquainted with all the thoughts, motives, and aspirations which a great master in art sought to give expression to in his works, the expedients by which he overcame the difficulties that arose, and the considerate care, forethought, and constructive skill by which the works planned were carried to completion. While in this position, Mr. Wilson had the good fortune to be engaged on Hamilton Palace, Lennox Castle, Toward Castle, the Royal Exchange, Campsie Parish

Church, St. Paul's Church, the Normal Schools, and some other large though less noted works.

Mr. Wilson entered Mr. Hamilton's office in 1827, and left it to begin business on his own account in 1837, in which year he designed Hutchesontown Church, Hospital Street. I have hung up a plan and elevation of this church, so that you may see the arrangements then deemed suitable, and the quality in architectural treatment then aimed at by Mr. Wilson. The arrangements are all good, though of the plainer sort, and perhaps the only part calling for special note is the recessed entrance and the very effective doorway, which is the central and most marked feature of the elevation. The details are all clear and elegant, though simple in combination, and all is in fine harmony. A high arched portal has never become a common feature in our churches—the why we cannot tell, for certainly we see how, even in so plain a design as this, a dignified effect may thus be gained. I cannot help recalling to your minds another good example of this high portal, by Mr. Stephen, in the Free Tron Church, North Dundas Street, and you will there see the idea more developed and enriched.

The church at Strathbungo was built from Mr. Wilson's designs in 1839, but remained minus its belfry till a recent time. The belfry is not by him, but is not out of unison with the original. The style is of Gothic type, the arches being round, not pointed, and though the details are all very simple they are well proportioned, and show a knowledge and appreciation of the detail peculiar to the round arched Gothic of Normandy.

About this time Mr. Wilson built another church, in which he showed a predilection for Greek art, and the marked success attending this effort makes one regret he did not meet with such encouragement as to lead him to prosecute more consistently this style. Many of his sketch designs of this period are strongly marked by a fine sense of the sweet placidity of Greek composition. I have only been able to exhibit a rough tracing of this church, Mr. Duncan's, which was built in Calderwood Street, off Parliamentary Road, and is now partly demolished, and converted into a workshop.

I have put up alongside a sketch design by Mr. Wilson of this date for a villa, that you may see in what direction his thoughts and inclinations were tending.

You will observe that the plan of the church is in the form of a cross, one arm being but slightly projected—and in this arm is placed the pulpit. Galleries fill the remaining arms, and the whole congregation is brought within a very moderate radius of the pulpit. This arrangement of plan you will find often recurring in Mr. Wilson's works, and, though not always so plainly expressed as here, you will find in all his churches the constant endeavour is made to have the bulk of the congregation gathered round within an equal and moderate radius of the preacher. Mr. Wilson's strong sense of the fitness of things withheld him at all times from adopting the long drawn aisles to Presbyterian churches.

In 1840 Mr. Wilson was employed in laying out the Botanic Gardens, and in building the gate lodge and curator's house. In the plan of this house you will observe a careful adjustment of the arrangements, with a view to preserve the comfort and amenity of the interior, and a strictly symmetrical disposition, combined with variety and good contrast in the outlines, resulting in a well-balanced and effective exterior, treated in a somewhat plain Italian manner, contrasting well with the rounded bossy forms of the surrounding trees and foliage.

I would direct attention to the manner in which the entrance is placed at the side, not in the centre of the front; how the corridor is lighted by a window in the end, and the staircase is at the side of hall. This was an arrangement not common in those days, even in the best suburban dwellings, but one you will find Mr. Wilson striving to perfect in all his best works. Let me endeavour, here and at once, to give you my explanation of the merits of this plan over the more common one of entering through the centre of the front into the hall, at opposite end of which is the principal stair. The entrance being at the extremity, and on side of corridor, offers an impediment to the rush of air when the door is opened, causing it to eddy round and loose its force before passing to the interior. The window at end lights up the corridor better than can be done by a glass door, and permits the inmates while passing through the corridor to enjoy a glimpse of the outer world and sky, without fear of being looked in upon by a chance caller.

A stand for flowers placed in this window adds a grace and charm to the interior, and when draped with curtains gives a feeling of warmth and comfort to the corridor, raising it in an æsthetic sense far above the prosaic aspect inseparable from the other, however highly decorated. Again, when the staircase is placed, not at the end of the lobby opposite the entrance, but on a side, you do not on entering look straight up the stair and take in at a glance the whole extent and appointments of the house, but as you advance the staircase opens out to view, and the light from its window streams down and across the lobby, producing a more pleasing and varied effect of light and shade. In the one case the lights streaming in from door and window at either end of hall neutralize each other, and the forms and details of door and staircase are thrown into shadow against strong lights, which fill the eye and prevent it resting quietly on the objects about; whereas, by crossing the lights from staircase and corridor windows, all objects in the hall are more clearly seen, the wall decorations are more equally lighted, and a more pleasing effect of light and shade is produced.

Bearing in mind these considerations, I will ask you to look at a design for a much superior villa, made for a Mr. Freeland in 1841. In it you will find the same careful symmetry of disposition, without formality. The entrance is again at one side, through a porch opening upon an inner hall of good dimensions, having in it a flight of steps by which the corridor of the house is reached. In the side of corridor is placed a wide handsome staircase, the window of which lights the corridor also. I have always regarded this design as one of the happiest of all Mr. Wilson's works. The elevations are beautifully proportioned, chaste, and effective; a classic feeling of breadth and symmetry pervades the whole, while the outlines and details have much variety and graceful, pleasing contrasts. Mark the effective setting of the openings, and the fine contrast produced by the fine rusticated basement.

About this time Mr. Wilson was commissioned to prepare designs for the Lunatic Asylum at Gartnavel, and preparatory to it he visited, along with Dr. MacIntosh, many of the best asylums in England and France. When finished, in 1843, it was considered one of the most perfect works of the kind in this country, and though, from some changes in the treatment of patients, it no longer holds a first rank as regards its internal arrangements, it is still held in high esteem by asylum authorities. Dr. Yellowlees, the present chief medical officer, states that "the construction and arrangements were far in advance of their day, and even yet compare favourably with many more modern asylums."

The buildings are divided into two blocks, for the reception of patients of a first and second class, and the space between is reserved for the erection of a church, when funds permit. In each block the same system of arrangements is adopted, which consists in having the entrance, reception-rooms, and officers' dwellings in the centre, with long galleries on either hand, running along the whole front between the centre and wings. These galleries are half width of the building, the half behind being divided into dormitories, each holding one bed. They are entered from the galleries, and lighted by windows in the back wall. The wings are occupied with wards, having several beds in each, attendants' rooms, and the requisite baths and other conveniences.

The elevations are designed in a somewhat plain Tudor style—a style well suited to the production of an effective pile of buildings, of an aspect sufficiently dignified and becoming for a great public work, and of moderate cost. An examination of the drawings exhibited will show how, with great sagacity, the style has been moulded to suit the necessary requirements.

On a near approach to the buildings, you find that there are no oriel windows, no projected porches, no clock-towers, with buttresses and high pinnacles, the usual constituents of the style; and you look to see by what means the rich group and picturesque assemblage of outlines, so attractive at a distance, has been brought about, and you find that it is produced chiefly by the disposition of the building into compartments, the centres and wings of which are projected, and raised one storey higher than the rest, and that a few pinnacles—some ten in all—on the angles of these projecting wings are carried high above the level of the parapets, and that what looked like pinnacles at a distance are the very necessary chimney stacks, so well disposed and outlined that they have an equally good effect when examined near. The walls are all finished with battlemented parapets, and these are enriched and varied so as to increase the elevating effect of the upright lines, which predominate in the fronts. You will see from the elevation shown that, should the church be carried out, and this design adhered to, the effect of the buildings will be greatly enhanced, and the unity of the group completed. The buildings cost about £56,000, and were completed in a little over two years, so that the architect must have had a busy time of it arranging all its varied details and attending to the great increase of commissions which the *eclat* of this work naturally attracted. In this design we have an example of how a large work may be arranged so as to be effective, enduring, and of moderate cost—the only purely ornamental parts being the parapets and pinnacles at their corners. I have sometimes thought that the introduction of parapets and balustrades added needlessly to the cost of buildings, and that with gables and overhanging roofs greater contrast and more effectual light and shade could be obtained; and so, I doubt not, it may, and that for cottages and private dwellings the overhanging roof is in many cases to be preferred. But, when we are dealing with public buildings, a primary duty is laid upon the architect, so to arrange the work that it will be very durable, seldom require repair, and will not necessitate that constant, watchful care inseparable from woodwork exposed to the malign influences of this climate. A judicious architect will therefore, in public buildings, refrain from using the more cheap and ornate wood cornicing in favour of the more costly stone cornice or parapet, even though the cost has to be made up by dispensing with some decorative features.

While the Asylum buildings were in progress, Mr. Wilson carried out many small houses on Partickhill, some tenements on Garnethill, a block of warehouses on north side of St. Vincent Street (between Renfield and West Nile Streets), and the toll-house which stood at head of Eglinton Street till a few years ago I have come upon the plans for this toll-house, and hang them up to show you how scrupulously careful Mr. Wilson was with everything entrusted to him. The arrangements will admit of careful inspection, and show how effective a simple mode of treatment may be made.

In 1845 Windsor Terrace was begun. This was the first built of the many palatial terraces which now adorn the Great Western Road, and in elegance of arrangements, quiet dignity, and graceful adornment it still holds its own among them, and is a very good exponent of Mr. Wilson's taste and skill in what may be called his favourite style. In this Italian *rennaisance* of a Florentine type many of his very best works have been designed, and the study of their treatment and effective details will repay the most careful examination. In this manner you will find one property at corner of Douglas and St. Vincent Streets and another on north side of London Street, all done in this year. He this year also started on a series of churches, mostly of a Gothic character; but you will observe that in this first church (Mr. M'Bride's Free Church, Rothesay) he prefers again the round to the pointed arch. I suppose his sympathies for Italian architecture may be the explanation. The drawing will show you the first spire designed and erected by him, and I would ask you to note how all the parts and outlines are so disposed as to increase the effect of the upward lines of the spire.

In the following year the Argyle Free Church in Oswald Street, and the [illegible] Church near the pier at Helensburgh, were built. In the first we have another example of his work in the Romanesque style, and in the second an example of his work in Italian design. Both are simply treated, and carried out with elegant and appropriate details. He was now in high esteem, and his services in much request, and I cannot note all that he had in hand, but will select for illustration Mr. M'Phail's house, Greenhead, now the Buchanan Institution; Mr. Freeman's house, in Crow Road, Partick; and the Glasgow Academy, now the High School.

In all of these designs the same spirit of elegance and simplicity which is very marked, and though they differ from each other in detail, they may be classed under the head of Italian design of Florentine character. The one villa is arranged on the strictly classic plan, and is entered through a portico in centre of the front, leading into a large square vestibule, which, again, opens straight upon the inner hall and staircase; whereas in the other villa the entrance is through a triangular porch placed at one side, having the inner hall and staircase disposed in the less strictly symmetrical manner formerly shown in Mr. Freeman's villa. The design for the Academy has always appeared to me the finest of Mr. Wilson's classical works—the forms of the openings and the wall spaces between are finely balanced and proportioned, the base, the centre, and the angles are boldly accentuated, and the details are all sweet in outline, and very effective in their light and shade.

In the year following (1857) Mr. Wilson's principal works were—St. James's Church, [illegible]; Maryhill Free Church, Manse, and School; the Exchange Investment Company's Building in Buchanan Street, opposite the Stock Exchange; [illegible] Priory, Loch Fyne; and the Greenock Cemetery. Of these I am able to show you the plans of Maryhill Church and the entrance gates of the Cemetery. In the church you will find him returning to the cross plan, having three galleries, one in each arm. These galleries are entered by stairs placed outside the church proper, in a somewhat peculiar manner, reminding one of the outside stairs seen in old country churches. The defect of this arrangement seems to me to be that the area under the front gallery must suffer in light, being dependent on the windows high up in the gables and on the borrowed lights from these stairs; but you will observe how this plan permits of the galleries being quickly emptied, without coming in contact with those leaving the area of the church. Though we have seen many subsequent attempts made to adopt this plan, retaining the independent exits, but approaching the galleries from separate outer doors, or from an aisle passage, we have not yet seen all defects removed or greatly modified, and commend the subject to your earnest consideration. The problem may, I think, be stated thus—To arrange a church on the cross plan, with galleries filling three arms, and to have the entrance to the whole by one door, the passage from that door to seats in galleries outside the area of church, or disposed in such a manner that a late-comer going to a seat in either gallery has not to run the gauntlet of the area as well as the galleries, with at the same time independent exits from the galleries.

The situation and laying-out of Greenock Cemetery has always been highly spoken of, and, though less attractive to the common observer, the entrance gateway has been admired by all having knowledge of architectural design. The design is very chaste and elegant, more severe in character than any other work of Mr. Wilson's that I know of. The details are all delicate and in fine harmony, inclining to more rounded outlines than pedantry may approve of, but all clear and distinct, bearing a distinctly monumental and funereal aspect, without that ponderous, gloomy look so often given to designs for similar works.

In 1848 Mr. Wilson's chief works were Lewis Castle, Raasay House, Free St. James' Church, London Street; the Southern Necropolis, and Messrs. Alexander's Mills, Duke Street; and in the year following I make note of Dudhope House, Dundee; Shandon House, Gareloch; Nelson Endowment Schools, Paisley; the Free Churches of St. Peter's and St. Stephen's, Glasgow; and the Free Church, Rutherglen.

I have been able to get together some drawings of Lewis Castle and Shandon House, and have to explain, in reference to the first of these, that the work was greatly extended at several times while the building was in progress; and, with regard to the second, that the centre part of front building is part of an older structure, which, being retained, hindered greatly the development of a successful plan.

There are two evils under which an architect has often to labour, regretting the opportunity now missed of developing more dignified treatment, with extended plan, or being obliged to retain a small part of an old house, by which his whole scheme is hampered, con [illegible] without [illegible]

[illegible] Mr. Wilson's [illegible] In Sandyford the [illegible] a window of [illegible] a handsome [illegible] Though a [illegible]

[illegible] Street was mentioned as one of the [illegible] because of its importance [illegible] an early application of corrugated [illegible] arches. The hall is fireproof, the lower floors are formed of brick arches, but the two upper floors are formed of corrugated arched plates resting upon iron beams [illegible] and filled up with concrete to level of floor, which is finished in [illegible]. The roof also is of corrugated galvanised [illegible] state that these iron arches and roof have stood the test [illegible] wear for 34 years, and are now [illegible] required no repair, and suffered [illegible].

[illegible] of the gateway at the Southern Necropolis, which shows to advantage Mr. Wilson's power in picturesque grouping and effective distribution of the lights and shadows [illegible] the masses seen in outline against the sky and of those produced by the wall openings and their adornments. The [illegible] and has in much of its details a [illegible] similar to that we have seen in Argyle Free Church and the church spire, Rothesay.

I have not been able to lay hands on correct drawings of St. James' Free Church, London Street, but show some drawings of Free St. Peter's, Free St. Stephen's, and the Free Church, Rutherglen. The two former of these churches you will see are nearly square on plan, with galleries on three sides, and, by the disposition of the iron columns carried up supporting roof and galleries, the ceiling is developed into a cruciform arrangement, having arched plaster vaults over nave and transepts, with intersecting ribs at their junction and groined ceilings over side aisles of nave. In the exterior elevations the cruciform plan is brought out prominently by high gables over the arms of the cross, and marked still further by means of great grouped windows, placed high in the gables. In these designs the aim evidently is to produce a compact group of outlines, increasing the apparent height of the building, and harmonising with the soaring lines of the spire.

The spires in both churches are placed at the corner where the streets intersect—not in the centre of the front, as had hitherto been the practice in Glasgow; and, though one would suppose this disposition obviously the most suitable, yet I may point you to the case of Blythswood Church, where the spire is placed on other side of front gable, next to the adjoining buildings, with disastrous effect. I suppose the intention in this case was to counteract the levelling effects of adjoining tenements by interposing the massive form and ascending lines of the tower, thereby preventing the tenements dwarfing the gable of the church nave; and, though this is secured, it is at the sacrifice of much of the general effect and the weakening of the base of tower, which appears to have sat down in a gap between church and tenement. The obstacles to the proper adaptation of Gothic forms to city churches are indicated by the cases I have cited; and I would ask you, bearing this in mind, to look at the front of Free St. James' Church, London Street, the first time you are that way, and you will see how effectually Mr. Wilson has in it overcome the levelling lines of adjoining tenements. The tower of Rutherglen Church is of very pleasing proportions, and the embattled and pinnacled top part is graceful and picturesque in composition, and forms an attractive feature in the ancient burgh. You will find few such simple, graceful, and effective terminations to the towers of modern Gothic churches.

1850-51. In these years we find Mr. Wilson more busy with mansions than with churches, though in these years he executed the Free Church at Melrose, one of his best, and at this time he also carried out the Royal Bank Buildings, Buchanan Street.

We will look at the church first, and follow up the remarks we had in view while speaking of those other city or town churches.

[illegible] buildings so designed [illegible] extremities of the elevations [illegible] [illegible] where it is placed at the side [illegible] St. [illegible] churches, where the tower is placed at the side where the walls of transept and [illegible].

The most important of the houses done at this time are [illegible] House, [illegible] House, [illegible], and houses [illegible] for Mrs. [illegible], Mr. [illegible], and Mr. W. E. Baker. The [illegible] of these are shown with the plans and elevation, and the staircase of [illegible] House, to an enlarged scale, shows a somewhat novel, appropriate, and vigorous mode of decorative detail.

In the distribution of these plans and in that of [illegible] House, [illegible] years previous, you will find the same general features—viz. the porch and vestibule at one angle of the building, the corridor entered from the side and lighted by window at end, the staircase [illegible] till corridor is partially traversed, and the dining-room placed on opposite side of corridor to the drawing-room. I need not refer to the elegance of this arrangement further than to say that though the position thus allotted to the dining-room seems dictated primarily by the convenience of access thus afforded for the service of the room, it is productive at the same time of one of the most pleasing effects, causing the company, while passing to it from the drawing-room, to form itself into a somewhat stately and graceful procession, contrasting most favourably with the short [illegible] march accomplished by a company passing from the one room to the other when they are placed in a line or adjoining each other—the space between being short and the turn abrupt, the company seem like one passing a turnstile. It would occupy too much time to go further into details of arrangement, but a careful examination of these plans will, I think, reward anyone who has had experience in grappling with the complex problems the designing of such houses presents, and I only note one feature pervading them which seems to me being lost sight of in many recent houses of a like class. It is this, all the chimneys are placed in inside walls, and consequently many thick walls are required to subdivide the interior. This seems to me to explain why many houses of greater cost and more elaborate groupings and details want in dignity of effect, and have a cheapened though pretentious appearance. The solidity in construction indicated by chimney stacks appearing through the roofs, back from the front walls, and the better grouping their positions there affords, lends an air of respectability to their exteriors, however plain, which the more ostentatious display of gables with chimney-heads never has.

The style adopted in Mr. Baxter's and Woodside House is Italian, and that of the other houses is a modification of Scotch baronial. In both you will find careful and judicious adjustment of the parts, grouping and contrasting agreeably with each other, moderately rich, without redundancy, as becoming the residence of a gentleman of means and culture. I have exhibited an abandoned design for Woodside House in a castellated style, as another example of the ability which Mr. Wilson possessed in handling that style, and which may afford you some pleasure to examine.

As exponents of the works being carried on in the next two years (1852-53), I have put up some drawings of a design for the General Post Office, Glasgow, and a picturesque villa, neither of which were realised; also plans of Lochton House, Dundee, and Free St. Paul's Church there. Besides these, Mr. Wilson had on hand Pitcullo House, Fife; Dunipace House, Larbert; Messrs. Gilmour & Thomson's warehouses, Argyll Street, opposite Mitchell Street; and Mr. York's properties, corner of Kelvingrove and Sauchiehall Streets.

In the year following (1854) he began a house at Dundee for Mr. Edward Baxter; the Faculty of Procurators' Hall, West George Street; and Kelvingrove Park, with its terrace houses and grand stairs.

In the design of Lochton House you will find a more rich and picturesque treatment of the Scotch baronial style, while the plan is exceptionally good in all its appointments, and is arranged upon the principles we have shown him to hold in highest esteem.

[illegible] dispositions, and [illegible] at this time for [illegible] considerably [illegible] from the ideal form in which the design was first presented. I have been able in this case to show the design in its more perfect form, before being shorn of some of its more attractive features in compliance with the needs or wishes of the client.

[illegible] because his client cannot find the means [illegible] designs, and he must be content to work within the limits of his client's [illegible] and desires. [illegible] when we suffer disappointment [illegible] case as exceptional [illegible] for, on looking through the old plans and sketch designs by Mr. Wilson, I have been particularly struck with the number of designs prepared, considered, and cut down, over and over again, before a final settlement was arrived at.

The Faculty of Procurators' Library I have exhibited by plan, elevation and enlargement of front to a large scale, so that you may examine the detail and the careful adjustment of all the parts; and I would direct special attention to the nice adjustment of the openings and wall spaces, the proportions of the entablatures, the rustication of the lower storey, and the richly-grouped and united effect of the piers and pillars in the upper storey. The jambs of the upper windows have carved and panelled ingoings, such as you will have noticed appearing from time to time in previous designs, always used with happy effect, and here seen to full advantage, giving depth and richness to the ingoings, and by their contrast bringing out more clearly the lines of the columns. I cannot pass on without adverting to the small surbase on which these columns are set. I remember that at the time I thought them unnecessary, but, having since then often seen columns and piers with their bases made to rest direct upon the copes of balustrades, or on the sill courses, I have noticed that the effect was inferior, for when seen at a distance the mouldings of base and copes appeared to run together. On a near view the projection of cope hid part of base, and an appearance of weakness under the column was the result.

In conjunction with Sir Joseph Paxton, Mr. Wilson at this [illegible] began the laying out of Kelvingrove Park and designing the houses in Park Terrace, Gardens, Circus, and granite stair. The most noticeable novelty in these designs was the profuse employment of oriels, and the carrying of them up through several storeys. In the lower terrace you will perceive that, while the oriels are as freely used, they are square on ground floor and octagonal above that level, and that the whole character of the elevation is broad and massive, harmonising with and forming a fitting termination to the houses of Claremont Terrace, while at the same time the level lines of their mass forms a fitting base and contrast to the picturesque groupings and broken and sweeping lines which characterise the houses that crown the hill behind. Mr. Wilson was commissioned by the Magistrates to design the elevations only, and in most instances designed the plans for the builders and proprietors, so that he had his hands well filled with these buildings for several years. The terrace was, I think, the first instance in which the Mansard roof was used in Glasgow, and the situation seems one eminently fitted for its employment. I sometimes wish the fashion had been less catching, or that equally good sites were found for all the multitudinous varieties we now see on all sides. The sweeping level lines of the terrace, with the high-crested roofs, and the projected parts rising at intervals into tower-like forms, terminating in these richly-wrought roofs, accords well with the swelling forms of the hill and luxuriant outlines of the wooded park, which seems gathered up into them as a fitting crown, and is a fine example of successful treatment; but I have not the same admiration for the design *per se*, or for its details, as I have for the design carried out in the houses of the Circus. This design seems to me more clear, delicate, and effective, and more after the spirit of Mr. Wilson's best works. The mode of rustication employed on the ground floor of the elevations to Circus are specially worthy of your attention. The granite stair will always form an attractive feature of the Park, and deserves to be named among the most successful works executed by Mr. Wilson. Its great width and height, and the beautiful material of which it is made, would of themselves make it remarkable, but its grandeur is enhanced greatly by the skilful disposition of the greater and lesser piers, and the towering forms given them. Should these great piers be ever crowned with suitable sculpture, the elegance and dignity of the design will be brought out and become better recognised.

I have exhibited the drawings of two villas designed in 1856. Both are in the Gothic style, and very similar in the plan and [illegible] [illegible] [illegible] [illegible] [illegible]. The one is very much [illegible] [illegible] [illegible] [illegible] may add, the more decorative features [illegible] [illegible] [illegible] [illegible] which it was finally adopted, and as it [illegible] [illegible] [illegible] [illegible] with the [illegible] house, I have [illegible] [illegible] [illegible] [illegible] [illegible]. The one was built on the [illegible] above [illegible], and now forms part of the [illegible] establishment; the other is [illegible] the road between Paisley and Renfrew. These [illegible] differ in some ways from those others I have shown [illegible] [illegible] [illegible] the advantages of having the porch and staircase [illegible] [illegible] [illegible] [illegible] and [illegible] access from kitchen [illegible] [illegible]. The [illegible] is nearly square, and the projections are [illegible] [illegible] [illegible] [illegible] the effect of the exterior perspective [illegible] [illegible] [illegible] [illegible] [illegible] [illegible], with piquant [illegible] [illegible] [illegible] [illegible] [illegible] disposed—few but well [illegible].

[illegible] [illegible] competition was not so much in vogue here [illegible] [illegible] [illegible] Free Church was the only one in which [illegible] [illegible]. Mr. Wilson had strong objections to this mode of [illegible] [illegible] [illegible] dislike to friendly rivalry with his brethren [illegible] [illegible] [illegible] [illegible] because the stipulated cost was generally [illegible] [illegible] [illegible] to the required accommodation. To [illegible] [illegible] the requirements stipulated would in most cases necessitate [illegible] [illegible] the whole buildings being constructed of common rubble. [illegible] [illegible] [illegible] [illegible] he declined to take part in them.

[illegible] [illegible] [illegible], he took part in the competition for the Free [illegible] [illegible] and College Church, and his plans were selected. [illegible] [illegible] drawings of these, that you may see the orderly [illegible] [illegible] in which the distribution of the plan has been [illegible], and the [illegible] and originality of treatment. This is [illegible] [illegible] of all the parts and appointments of the [illegible] [illegible] [illegible] [illegible] appropriate, and eminently ingenious. [illegible] has hitherto been so much the fashion for our churches [illegible] [illegible] [illegible] grand and beautiful interior has not had the influence [illegible] [illegible] [illegible] [illegible] [illegible], as the tide seems now to have [illegible] the [illegible], we may hope to see more of our city churches [illegible] upon the principles embodied here, believing them to be [illegible] [illegible] [illegible] [illegible] modern requirements, and more expressive of our [illegible] [illegible] [illegible] and art.

While the College was in progress the Queen's Rooms and buildings of La Belle Place were begun, and you will see from the plans exhibited how admirably the arrangements have been adapted to the very limited area occupied by them. This was one of the few instances in which Mr. Wilson was permitted to avail himself largely of the sculptor's art, and you will note the disposition of the elevation, by which the sculptured decorations are fittingly framed and adequately relieved. When the ball-room was first used great fear and trembling came upon the dancers when they found the floor yielding and responding to their elastic motion; but all else remaining stationary, their confidence returned, and they were pleased to learn that the architect had so designed the floor that it should yield and rise under their moving weight, without loss of stability. The flooring joists pass through iron trellis beams, and under each joist are laid pads of india-rubber—hence the spring in the floor.

In the two following years the works executed were Thornliebank House; a house near the Sailors' Home, Greenock; a house at Dundee, for Mr. Armitstead; a villa at Blairmore; and several villas and cottages at Garelochhead and Rahane.

I have shown a photograph of Thornliebank House, and by it you will see that it is after the style of Lochton, modified to suit some circumstances. I also show Mr. Steel's house at Greenock, being in many ways different from any of his former designs. In this plan he adopts the strictly classic arrangement, entering at the centre of the front, with portico opening direct upon the middle of the hall. The inner hall is after the manner of a cortile, open through both floors, and lighted by cupola above, and all the apartments are entered direct from these halls, and all fireplaces are placed in the four walls which enclose them. You will observe that the staircase is not seen from the hall, but is placed in a corner, and is kept quite subordinate. Being thus set apart as the approach to the private apartments only, it is available also as the service stair to bedroom floor.

I show you also designs in Gothic and classic form for a Free Church, which were designed at this time. They were submitted in competition, the Gothic design being accepted, and working plans and full details prepared. Some cause of disagreement subsequently arose among the promoters, and the scheme was abandoned. You will, I think, agree with me that the misfortune is one we have all reason to regret, as the design possesses a novelty and grace beyond any of Mr. Wilson's Gothic structures, and the example might have raised the public sentiment to the appreciation of Gothic design, in which all modern desires are freely responded to and assimilated without close adherence to precedents or implicit imitation of them.

Mr. Wilson died in February, 1863, and Glasgow was then in very similar circumstances to what we find her to-day—recovering slowly from a great and scandalous commercial convulsion. During the last few years few works of importance were carried out, but they include two of his best works in Scotch baronial—viz., Wester Moffat House and Rutherglen Town Hall. These were the last he lived to finish, and amongst those in hand may be noted Eastwood Church, St. John's Episcopal Church, Oban, and the Great Western Hotel and terrace there.

I have exhibited drawings of the Town Hall, Rutherglen, and Wester Moffat, and will content myself with a very few remarks concerning them. The requirements of the burgh necessitated a lesser hall, some offices, and shops on the ground floor, and the public hall had therefore to be placed above them, thereby producing a large high edifice in strong contrast to the low rows of houses forming the background, and seeming to overpower the whole surroundings; but as the street is being rebuilt with tenements this is disappearing, and the effect of the hall and town is become more harmonious.

You will observe how well the shop fronts are managed and brought into harmony with the massive proportions of the structure, and note also how that the great hall is expressed by the large oriel window in front gable, and how the gable is broken up, adding greatly to the enrichment and picturesque effect of the elevation, while it lessens the apparent breadth and height of the gable, thus diminishing in some measure the overpowering effect of its bulk. The details are all well worthy your careful examination, and I may here state, for the benefit of the curious in constructive detail, that the whole corbelling of oriel window, which is 16 inches wide between scuntions, is carried out without any beams or other backweight on their tails, or iron joggles in their joints.

Wester Moffat is designed with a view to produce a pile of a high castellated character, more like the old baronial fortalice than any of those other designs I have shown you, and in this it is very successful. The area of the plan has been kept as small as possible and brought nearly to a square, while the building has been raised upon a basement and carried up to a third floor, with a square tower over entrance and high turrets on the angles.

There are no lower buildings attached to the main part, detracting from its height, and the whole presents an assemblage of high pointed and picturesque forms, which group themselves up, and form a design of great boldness and variety. There is an air of compactness, breadth, richness, unity of effect, and variety of detail about this house which I have seldom seen equalled; but, as is always the case, something has been sacrificed for it, and I reckon one of those things to be the placing of the kitchen offices in the basement.

The drawings I have been able to show you are a more eloquent exponent of Mr. Wilson's abilities as an architect than any comments I can make on them; but I trust the remarks I have made, hasty and fragmentary as they have been, may not be altogether unprofitable, or devoid of interest to you; and, though I feel that I have not laid sufficient stress upon the artistic conceptions and treatment embodied in these designs, I have perhaps said enough to lead you to a more careful examination of any of his works that you may chance to meet with, and by seeing so many brought together you may the more readily recognise them.

Artists—that is to say, painters in oil and water colours—are very much given to pooh-pooh the claims of architects to be considered artists, on the plea that works of fine art are the product of the artist's individual mind and hand, whereas the architect's conceptions are all worked out by the hands of craftsmen; but one primary quality in a true artist's work consists in the harmony and individuality of expression which characterises and pervades all he touches, and makes the recognition of the master's hand a matter of ease and certainty to the qualified connoisseur, and you cannot leave the examination of these designs without being impressed by their strong individuality and unison of expression, notwithstanding the variety in their style and subjects.

XV.—*Action of Ammonia on Fats at a High Temperature.*

By T. N. Whitelaw.

[Read before the Chemical Section, 20th March, 1882.]

In the ordinary way of conducting the hard soap manufacture a considerable amount of glycerine will remain mixed with the soap after the first running of spent lye, and from the great bulk of the soap a second washing, while giving a dilute glycerine, with a relatively large quantity of salt, will still leave glycerine far from perfectly removed.

Again, in the soft soap manufacture the glycerine is left in the soap, where it probably serves no useful purpose, as good soft soap can be made free from glycerine.

Considering such points, it appears desirable to find some process by which the glycerine may be removed from the fats before beginning the soap manufacture.

The decomposition of the fats by ammonia seemed a possible method of obtaining glycerine readily in a pure state, and the following experiments were undertaken to see if the fats, after treatment with ammonia at a high temperature, were in a condition suited for the manufacture of soap:—

One part of cotton-seed oil was heated in a sealed tube, with rather more than an equal volume of strong aqueous ammonia.

After continued heating to 100° C., no distinct decomposition seemed to take place, but after 24 hours, with repeated agitation, the bulk of the oil came to the surface, apparently unaltered. Even up to 110° C. there was no marked effect, but from 110° to 120° C. the oil became decomposed with comparative rapidity, and a clear, amber-coloured thick liquid took the place of the previously turbid mixture of oil and ammonia, indicating clearly that decomposition was complete. When cold this appeared as a soft, yellowish-white, opaque, soap-like mass. On heating for two or three hours in the water bath the ammonia was driven off and an oily substance left, with a distinct sweet taste, which on washing yielded glycerine. The washed oil was heated with water, and weak caustic soda solution added, drop by drop, when combination took place and a soap-like body formed; but in presence of a very slight excess of caustic soda the soapy compound was rendered insoluble, and coagulated into a tough mass. A similar insolubility was observed in presence of a trace of common salt or carbonate of soda. This at once showed that the oil was different from ordinary fatty acids, of which the soaps are more soluble in dilute caustic soda or salt solutions than in water. On adding considerable excess of caustic soda and boiling, no change took place until the solution became concentrated, when evolution of ammonia occurred, becoming copious on fusion.

By this process, although the glycerine is readily obtained, the oil is darkened in colour, and so modified as to be unsuited for soap-making, and the operation of driving the ammonia off by fusion with caustic soda seems difficult and impracticable.

The change in the oil seemed to be due to the formation in some quantity of amides of the fatty acids, similar to those first examined by Bouillay in 1843, and further experiments were undertaken to find if this were really the case.

The previous production of those amides was by digestion of the oils for some months with aqueous or alcoholic ammonia, and Carlet had only with the solid fats used the temperature of the water or salt-water bath, in which case he took from fifteen to twenty days to get complete decomposition.

In my experiments tallow cake, palm oil, almond oil, cotton-seed oil, rosin, and crude palmitic acid were heated to 120° C., as previously described, with one to one and a half volumes of aqueous ammonia, and in each case, within from three to six hours, a distinct change from turbid mixture to clear, soap-like solution indicated the completion of the reaction.

In the cases of almond oil and cotton-seed oil, where the ammonia was perhaps more distinctly in excess, after four to five hours' heating, a separation into two layers seemed to indicate undecomposed oil, but, on closer examination, both layers were found to be quite clear and soap-like, the separation being due probably to insolubility of the amide in aqueous ammonia. On cooling, the ammonia (of which the greater portion seemed to be combined with fatty acids, as ammonia soap) was neutralised with weak hydrochloric acid, and the oil obtained clear by boiling, washed, and dissolved in alcohol.

In the case of tallow cake, the melting point of the modified oil was 28° C. higher than that of the corresponding fatty acids obtained by saponification of the tallow cake with soda and decomposing with acid.

The solutions of the oils from tallow cake, palm oil, and cotton-seed oil, on cooling deposited white crystalline nodules, which, when purified by several crystallizations from alcohol, had the following melting points (taken in a capillary tube, suspended with a thermometer in water, which was gently heated) :—

Tallow (stearamide), ...	101° C.	Probably still impure.
Palm oil (palmitamide), ...	96°	
Cotton-seed oil (?), ...	98°	

Being sufficiently near to Carlet's melting points of 107·5 for stearamide and 101° C. for palmitamide, if allowance is made for the different methods of taking them.

The properties of those bodies corresponded with the amides described by Bouillay in 1843, Rowney 1855, and Carlet 1859—insoluble in water, soluble easily in hot alcohol, crystallizing from it in white nodules, not decomposed with boiling solution of caustic soda, but decomposed by fused caustic soda with evolution of ammonia.

The solution of modified almond oil in hot alcohol did not give any crystals, though other indications of the presence of an amide were given, and I have failed to get any body corresponding to oleamide.

The palmitic acid, heated with ammonia, seemed to yield simply ammonia palmitate, as palmitic acid was recovered from it unchanged.

Rosin was darkened in colour and modified in odour, but did not seem to be otherwise altered in properties.

XVI.—*The Composition of some Fossil Eggs from the Peruvian Guano Deposits.* By John Clark, Ph.D., F.C.S., F.I.C.

[Read before the Chemical Section, 9th March, 1882.]

Some time ago Mr. J. H. M. Fallon very kindly forwarded to me a number of fossil eggs from the Peruvian guano deposits, and as I thought their composition might interest this Society, I resolved to lay before you the results of my analyses.

According to information derived from Mr. Fallon, the eggs were found in deposit No. 3 on the principal island of the group, called the "Islands of Lobos de Afuera," at depths varying from about 2 feet to 25 feet from the surface. They are of two sizes—as you will observe from the specimens which I produce—the large eggs being those of the pelican (*Pelecanus tagus*), called on the Peruvian coast the alcatraz, and the small eggs those of the potoyunco or *Puffinuria Garnotii*.

These eggs appear to differ materially in their composition, and I shall therefore treat of them separately.

Pelican's Egg.—The specimen of the pelican's egg which I examined was about the size of a goose egg, the shell—of which only a small portion remained—was black in colour, and the interior, which was completely filled, consisted of two materials corresponding respectively to the white and the yoke of the egg. The portion representing the white of the egg formed the bulk of the contents. It was yellowish-white in colour, of a somewhat silky lustre, and translucent crystalline appearance.

The part representing the yoke was black in colour, and of a somewhat resinous aspect, and it formed a very small proportion of the contents. As the quantity of dark-coloured matter in one egg was too small for a proper analysis, I picked out the dark-coloured portions from several eggs, and separated the white as completely as possible.

Potoyunco's Eggs.—The interior of the small eggs was almost entirely filled with crystals of a somewhat pearly lustre, and contained very little of the black matter corresponding to the yoke.

ANALYSIS OF PELICAN'S EGG.

WHITE PORTION.

	Per Cent.
Potassium Sulphate,	34·48
Sodium Sulphate,	10·45
Ammonium Sulphate,	8·70
Ammonium Oxalate,	31·07
Ammonium Chloride,	1·12
Ammonium Phosphate,	2·21
Free Acid,	traces.
Soluble Organic Matter, &c.,	2·74
Insoluble Organic Matter,	·93
Calcium Phosphate,	1·58
Silica,	·02
Water,	6·70
	100

Nitrogen, . . . 9·62.

BLACK PORTION FROM SEVERAL EGGS.

		Per Cent.
Sol. in Water.	Potassium Sulphate,	2·70
	Sodium Sulphate,	·95
	Ammonium Sulphate,	1·58
	Ammonium Oxalate,	4·95
	Ammonium Chloride,	7·08
	Ammonium Phosphate,	5·86
	Free Acid,	traces.
	Soluble Organic Matter,	23·15
Insol. in	Organic Matter insoluble in Water and Ether,	16·30
	Fatty Matter soluble in Ether,	27·50
	Calcium Phosphate,	3·93
Water,		6·30
		100

Nitrogen, . . . 9·01

ANALYSIS OF SHELL.

	Per Cent.
Phosphate of Lime,	70·33
Oxalate of Lime,	none.
Carbonate of Lime, Alk. Salts, &c.,	29·67
	100

ANALYSIS OF POTOYUNCO'S EGG.

WHITE PORTION.

	Per Cent.
Potassium Sulphate,	65·95
Sodium Sulphate,	17·98
Ammonium Sulphate.	10·70
Ammonium Oxalate,	none.
Ammonium Phosphate,	1·74
Ammonium Chloride,	·85
Free Acid,	traces.
Soluble Organic Matter, &c.,	·40
Insoluble Organic Matter,	·83
Calcium Phosphate,	·56
Silica,	·15
Water,	·84
	100

Nitrogen, ... 2·95

When we compare these analyses, the most striking point of difference is the ammonium oxalate, which is present in the large egg to the extent of 31 per cent., and absent in the small one. I am not aware of the exact depth at which the specimens analysed were found, but I am inclined to think that the small egg came from a greater depth than the large one, and, judging from the results obtained by Rose and Raimondi, I am of opinion that the proportion of oxalate of ammonium decreases with the depth. The question also very naturally arises—What is the origin of the substances found in the interior of these eggs? The large amount of potash which they contain renders it impossible that the salt can have resulted wholly from an alteration of the original contents of the egg, and they must therefore be derived in part at least from infiltration, which probably takes place by a species of endosmosis. We know, at any rate, from the investigation of Chevreuil, that oxalate of ammonium and potash salts are normal constituents of Peruvian guano; and according to Shephard, there is a mineral, which he has called guanapite, found in rounded masses and veins in the Peruvian deposits, which consists of sulphate of potassium, sulphate of ammonium, and a small quantity of oxalate of ammonium, so that we have no difficulty in tracing the source of at least a great portion of the constituents of these eggs to the guano itself.

XVII.—*Notes on some Investigations in Chemical Physics.*

By J. B. Hannay, F.R.S.E., F.I.C., &c.

[Read before the Society, 29th March, 1882.]

The investigations upon which I have been engaged for the past two years are of a kind which, while they do not in themselves yield any striking results, do nevertheless prepare the way through which we may gain entrance to a region as yet untrodden by investigators.

The chemistry of the present day has been developed in the direction of easiest progress or "least resistance," and hence all the results obtained are of one type. If we treat the entire region of chemical investigation as space of three dimensions—the dimensions being temperature, pressure, and time—then we find that if we consider one of these measures—pressure—the whole science of chemistry has been developed along that pressure we call one atmosphere or ordinary pressure. When compared with the pressures produced by the attraction of molecules, this pressure is a very small one indeed. The range of experiments in temperature is also very limited, while the relation of time to chemical action is only now being touched upon by chemists. A complete knowledge of the velocity of chemical changes would yield us information of the probable mechanism of those changes, and is one of the most important elements with which chemists can deal. Pressure, on the other hand, giving us measures of velocity and elasticity, is of great importance in yielding us knowledge as regards the mechanical constitution of matter, and, as it is governable, it may be used to cause chemical action to proceed in whatever fashion we may desire. I had the pleasure of showing to this Society some years ago that the present chemistry was entirely moulded by the one agent—water—and that if some menstrum other than water were used a quite different chemistry would ensue. I showed that the constitution of bodies might be quite different from our present conception of them, and also that elements other than carbon might become the basis of organic systems, provided that water be excluded.

It is now my pleasing task to lay before you the results of the preliminary work undertaken, with the view of ascertaining whether other systems of chemistry might not exist besides the one atmosphere-pressure chemistry of the present day. In carrying out this work, it was often found convenient to associate high temperature with pressure, as the increase of temperature, by increasing the molecular velocity, decreased the time required for the completion of a reaction.

The experiments which had already been made upon liquid matter at high temperature and pressure, had left the question as to what condition any temperature and pressure corresponded to in a quite unanswered state.

Cagniard de Latour, the earliest worker in this field, noticed that, when a liquid inclosed in a glass tube was heated, a point was reached where the meniscus, indicating the existence of liquid, disappeared, and the contents of the tube became, according to his idea, gaseous. Dr. Andrews entered into a long investigation of the pressure of the saturated vapour of liquid carbon dioxide, and came to the conclusion that, under given conditions, the liquid and gaseous states of matter were continuous. After two years of continuous investigation, with a great variety of substances, I have arrived at the conclusion that the liquid and gaseous states of matter are always capable of definition, and are not more continuous than are the solid and liquid states of matter. In the discussion of such a subject as the states of matter, it is absolutely necessary that the states spoken of should be clearly defined, and that the definition should admit of experimental proof, and it is in these two points that Andrews, for the want of correct definition, drifted into the position of uncertainty which his Bakerian lecture shows he occupied. The definition which I have adopted, as describing a liquid, is—a fluid which exhibits surface tension. This is the whole index of the liquid condition. A gas, on the other hand, is a fluid which does not exhibit this property, and which mixes in any proportion with any other gas. These definitions are capable of being put to practical test, under any condition, where matter is observable. The only test applied by Andrews to the fluid with which he was experimenting was that of pressure. Now, the tension of the vapour of a substance is one of those phenomena which has not yet received its real explanation, [illegible] [illegible] [illegible] [illegible] [illegible] and liquid conditions [illegible] [illegible] [illegible] [illegible] pressure are similar to the [illegible] [illegible] [illegible] [illegible]. [illegible] pressure is not [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] so that measure[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to speak with any [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] in his [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] a little over its [illegible] [illegible] [illegible] [illegible] [illegible] to answer this question? [illegible] [illegible] [illegible] pressure [illegible] [illegible] [illegible] could reach him [illegible] [illegible] [illegible] [illegible] [illegible] a liquid. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] surface tension [illegible] [illegible] [illegible] [illegible] not a liquid, but is a gas. [illegible] [illegible] [illegible] [illegible] in which his experiments [illegible] [illegible] [illegible] [illegible] [illegible] was placed in a bath [illegible] [illegible] [illegible] [illegible] [illegible] the experimenter [illegible] [illegible] [illegible] [illegible] was required. Now, so [illegible] [illegible] the pressure was lower than that [illegible] by the vapour [illegible] the [illegible] [illegible] [illegible] [illegible] seen as a liquid, exhibiting a surface [illegible] [illegible] [illegible] [illegible] as we say, a meniscus. [illegible] [illegible] the pressure was greater than that exercised by the vapour of the liquid, [illegible] [illegible] [illegible] the free space over the mercury. [illegible] [illegible] [illegible] whether we have liquid or gas? [illegible] [illegible] [illegible] there is no visible mode of answering. [illegible] [illegible] [illegible] the temperature till a temperature was reached where [illegible] [illegible] [illegible] was certainly gaseous, and then [illegible] [illegible] [illegible] [illegible] [illegible] by an apparently perfectly continuous [illegible] gas is [illegible] from liquid. But still [illegible] [illegible] [illegible] the question. Liquid exhibits surface tension, which means [illegible] [illegible] [illegible] repulsion, or the negative of cohesion. There must be a point where the cohesion of the liquid disappears and the [illegible] of the gas comes into existence; in other words, there must be a limit to the liquid state, which is the commencement of the gaseous state. There are two forces at work in both states—the attraction of the molecules for each other and the repulsion resulting from the thermic motion, which gives pressure to a gas. The attraction may be a fixed quantity always the same, and it is only the thermic rectilinear motion which varies. However that may be, there must be a point where the two forces equal one another—that is, ever so little before that point the fluid has cohesion, whether it be visible or not, and ever so little over that point the fluid has negative cohesion or repulsion. Now, as the repulsive force (the one which varies) depends upon velocity, and not at all upon density—that is to say, it depends upon the force of the blow one molecule can give another, and not at all upon the number of molecules moving—the point where the liquid state ends depends entirely upon temperature and not at all upon pressure. The critical point discovered by Baron Cagniard de Latour, and made the subject of careful investigation by Andrews, is the only point where the direct passage from gas to liquid can be visible, because at any lower pressure the liquid boils, and at any higher pressure there is no free surface to observe any change. The question I put to myself early in my investigations was—Is there any method of obtaining a free surface at pressures greater than the "critical"? And I found that there was. Hydrogen gas is almost insoluble in many liquids quite up to their critical points; in fact, I believe in some cases the solubility decreases with the rise of temperature, notwithstanding the great rise in pressure. In this way a large number of experiments were conducted, and are embodied in a paper read before the Royal Society,* in which it is clearly shown that at any pressure (up to at least three times the critical pressure) a fluid exhibits capillarity, or surface tension, and will not with a gas so long as its temperature is under the critical temperature; but it ceases to exhibit these phenomena, and diffuses perfectly into any other gas the moment its temperature is raised a fraction of a degree over the critical temperature. From this it will be seen that the liquid and gaseous states are no more continuous than are the liquid and solid states in the case of a solid, which does not change its volume on liquifying. So we see that Andrews mistook continuity of pressure for continuity of state. Although there is no change of volume at the critical point, there is change of state, and the case could be paralleled by compressing liquid water till its freezing point was lowered to that temperature where its liquid and solid volumes were equal. In this state it would be impossible, without the intervention of a third substance, or some dynamical method, to tell whether the water existed in the liquid or solid form. Apparently the solid and liquid states would be continuous, and measurements of pressure would support this view, just as they did with Andrews. But the water would exist in one state or the other.

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* Proc. Roy. Soc., No. 218, 1882.

While working at the experiments on the limit of the liquid state, I found that some gases when compressed over liquids dissolved in them, and when this was the case it was invariably found that by increasing the pressure and temperature chemical action ensued. Thus we see that solution is, as it were, a very faint chemical action. Another fact observed was that the extent to which chemical action took place depended on the pressure. Thus in one case—carbon tetrachloride with hydrogen gas—when the pressure was suddenly increased, the manometer rose and then fell back to a little above the initial pressure, a portion of the hydrogen being absorbed by the liquid. This was not again liberated on releasing the pressure, but was chemically combined. On increasing the pressure, more and more hydrogen was absorbed, till ultimately some chloroform, or a body resembling it, was formed. The quantities obtained were far too small for analysis. On mixing oxygen with the vapour of nonane C_9H_{20} and compressing to 130 atmos., the mixture exploded at a temperature of 280°, whereas without compression a temperature of 300° will scarcely cause combination. But, further, a mixture of nonane and oxygen compressed to 200 atmos., and left at the ordinary temperature, gradually combine, as in a few days the pressure of the same volume gets reduced to 170 atmos., showing a disappearance of the free oxygen. So it is with other mixtures. A very high pressure causes the substances to combine whenever such a combination is effected by an evolution of heat, and hence a decrease of volume. It was noticed that nearly all bodies which are capable of combining will certainly do so on reaching the critical point of the least volatile constituent. It appeared from this that the critical point or liquid limit ushers in an important stage in the dynamical state of fluids, and for this reason it was determined to ascertain the temperature and pressure of this point in several fluids which are chemically similar. For this reason, series of alcohols, ethers, acids, and olefines and paraffins were chosen and submitted to examination, but as this kind of work involves the preparation of the pure compounds as well as their examination, the work will not be completed for some time yet. Such results as I have obtained, however, I will lay before you. The five alcohols methyl, ethyl, propyl, butyl, and amyl, were carefully purified from their commercial impurities, and distilled off quick lime till their boiling points were constant. Portions of them were then examined in the pressure apparatus, and their critical points determined, when it was found that the increase of complexity in their composition was accompanied by a rise in the temperature and a fall in the pressure of the critical point. The examination of the ethers and acids is not yet sufficiently advanced to yield any definite information, but the olefines and paraffins have been examined in sufficient series to draw some conclusions. Thus from an examination of the three olefines, amylene, heptylene, and octylene, it is found that at their critical points they all exert the same pressure, but for every addition of CH_2 the temperature rises by about 31°. An examination of the paraffins, sextane, septane, octane, and nonane, shows that while the temperature of the critical point rises with every addition of CH_2, the pressure falls. From this fact we find the very curious conclusion that with increase of complexity the liquid and gaseous states gradually approach each other till there would be only one boiling point—the critical point.

Capillarity may be taken as an index of the liquid state, in so far as it exhibits to us as a surface of liquid raised above, or depressed below the general level, owing to its reaction with a solid. An examination of the capillary height of a liquid at different temperatures reveals the fact that the height decreases with rise of temperature, till the critical point is reached, when the levels outside and inside the finest tube are equal. Here, then, we have a mode of measuring the amount of attraction of the liquid molecules, or of determining the liquidness of a fluid. It was found that at whatever pressure this might be tested—the pressure merely of the liquid's vapour or high pressure obtained by compressing hydrogen over the liquid—the capillarity always became zero at the temperature of the critical point. And this is found to be the case. Curves were drawn from observations of the variations of vapour tensions with temperature and points of equal vapour tension marked on the curve of each alcohol. The alcohol was then heated to that temperature, and the capillary height noted in a standard tube kept for these experiments. It might be thought that all liquids, at equal vapour pressures, would rise to an equal height in a capillary tube. But such is not the case. Take the two bodies amylene and octylene, which have the same pressures at their critical points, but these points are separated by nearly 100°, and we find that at the temperatures of 10° and 66·5° respectively, where their vapour tensions are equal, their capillarities are in the ratio of 6·7 to 7·2. It will be seen, however, from

[illegible]

[illegible]

[illegible]

cleaned, then filled with fusible metal, and inverted in a bath of the same metal, leaving a torricellian vacuum at the top. The glass at the top was then heated slowly till it began to soften, when sufficient gas was given off to lower the barometer by about 3 mm., and on cooling, a permanent depression of 2 mm. remained. The results of a long investigation of vacua will shortly be published in the Phil. Mag.* Suffice it to say that from this investigation it became clear that glass is penetrable to gas to a very serious extent, and any so-called vacuum is very rapidly deteriorated by the gas escaping from the glass surface. I have attempted in several cases to estimate the rate at which this deterioration takes place; but my results are very discordant as yet. I have examined several other surfaces, such as silica and calcium sulphate, and I find they are also permeable to gases. Now, here we have apparently the most impervious surfaces penetrated by gases, and I have endeavoured to picture to myself what goes on during that penetration, and what kind of bodies they must be which constitute the gases which have this power. And I cannot conceive of hard impenetrable spherical atoms acting in this way at all; but such atoms as Sir Wm. Thomson has done so much to establish as realities, I mean vortex atoms, would just act as my experiments lead me to see that air does. The air clings to the solid with very great force, and, after a long time, gradually insinuates itself between the molecules, making up the solid, till it has penetrated some distance into the surface; and it is only upon making the surface soft, and removing the air from the surface, that these molecules which have penetrated make their way out again. It has been shown by other experimenters that solids under enormous pressure behave like liquids, and react upon each other, as though they had the power of diffusing into each other; and we also find that under great pressure the properties of gases approach nearer those of solids, as they can be made to interpenetrate.

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* Now published, Phil. Mag., Apr., 1882.

XVIII.—*Report of Examination of a diseased Salmon from Loch Tay, received 4th March, 1882.* By JOHN DOUGALL, M.D.

[Read before the Society, 12th April, 1882.]

WEIGHT, 31½ lbs.; length, 44 inches; girth, at root of first dorsal fin, 23 inches; sex, male.

The upper part of the head from the snout to an inch past the eye on both sides, the alveolar ridges, part of the palate, the whole of the lower jaw, the lower part of the gill-covers, the breast to about 2 inches beyond the pectoral fins, the anal fin, and a small portion at the root of the tail, were more or less covered with a dark, brownish-crimson, spongy coating, measuring at its thickest part about a line in depth. From the first to the second dorsal fin, and somewhat from the latter fin to the tail, also on the root of the tail, there was a gelatinous deposit or coating not unlike coagulated lymph. This deposit could be easily peeled off, but small filaments or processes from it were found adhering to the lower surfaces of the scales.

Portions of this false membrane from the inner part of the mouth could also be easily peeled off, leaving the under surface in some parts normal, while in others the epidermis is wanting.

The coating I found to be very spongy, and to contain 88 per cent. of water. A cold aqueous solution of the coating was highly albuminous; and a minute portion of the juice pressed from it and placed under a ¼-inch object glass of the microscope was found to contain myriads of translucent, and particularly of opaque, micrococci in active motion. I cannot say definitely whether this motion was Brownian (*i.e.*, physical) or vital.

I observed also little bundles of fibres, but could not find in these any evidence of spores.

The internal organs were quite healthy; there was no milt nor tape-worm; and the stomach contained a quantity of the usual thickish cream-coloured matter which is found in most salmons' stomachs.

The fish was in splendid condition, the muscles firm and pink in colour.

XIX.—*On the Mode of Mental Inter-communication in Thought-willing and Thought-reading.* By Henry Muirhead, M.D., Cambuslang.

[Read before the Society, 12th April, 1882.]

Doubtless it will be in the recollection of some of our members that, at the meeting of the British Association in Glasgow in 1876, Professor Barrett, of the Royal College of Science, Dublin, read before the Anthropological Department a paper, entitled "On some Phenomena associated with Abnormal Conditions of Mind." In that paper he described to the audience certain phenomena which he himself had induced, and had experimented on in a purely scientific manner, with no darkening-down of lights, no concealed recesses, no professional medium. The discussion of the paper gave rise to considerable display of feeling, and the Professor was severely blamed, both then and afterwards, for bringing such a disreputable subject before a scientific assembly. At the same time it was—at least to my thinking—abundantly evident that he was actuated by true scientific motives, and an earnest endeavour to examine, dispassionately and accurately, the peculiar manifestations that had come under his notice.

I may probably to some extent share the fate of Professor Barrett, and be severely reprehended for bringing this tabooed subject before a society styled philosophical, more especially since I cannot pretend to much practical acquaintance with the subject-matter of controversy. But, as an onlooker may sometimes catch sight of something overlooked by the performers—and I fancy I have caught a glimpse of a point of view of considerable importance in the interpretation of some of the phenomena exhibited, a purely physical, and, it may be, scientific explanation of some of the startling departures from accustomed modes for acquiring information and inclinations—I have dared to bring my view before you, and, through you, before the scientific world in general.

Professor Barrett related a number of his own experiments with unsophisticated, and therefore trustworthy, subjects. For example, a young girl, who had never been out of her native place in the south-west of Ireland, being in mesmeric trance, he took her in thought of a shop he had frequented in Bond Street, London. She described to him the shop and its contents, much as he himself remembered them—that is to say, the objects which he had known and recalled to memory became known to the girl while in the trance. I merely give this as a sample case, and do not burden my paper with others, since most of you must have read of similar cases elsewhere.

I own that my mind was somewhat exercised to account for these unexpected developments. Now, with regard to the notion of the intervention of departed spirits, that seemed to me out of court altogether. Millions, nay, billions of people have watched millions of death-beds without having seen or heard a spirit departing, though I myself have seen a window set open for the purpose of allowing the spirit a free passage out to the unseen world. It is only in fiction that the Ancient Mariner relates—

> "Their souls did from their bodies fly
> To either bliss or woe:
> Each with a whizz did pass me by
> Like the whizz of my cross-bow."

Well, it so happened that at the very next meeting of the British Association (viz. at Plymouth in 1877) the telephone was brought, and for the first time exhibited publicly to a British audience when Mr. Preece, on a Saturday evening, delivered a lecture on "Telegraphy and the Telephone." On the latter being exhibited and its powers explained, the thought flashed upon my mind—"Here we have a mode of communicating ideas which, it seems to me, may afford a scientific explanation of mind-reading manifestations"—and immediately on leaving the lecture-room I wrote to Prof. Barrett to the following effect, as far as I recollect:—

"In listening to Mr. Preece's lecture it has struck me that telephonic phenomena will enable us to arrive at a philosophical interpretation of those that occur in mind-reading, clairvoyance, &c.

"In telephonic communications we have the following:—A, with the assistance of his brain, conceives certain ideas, and the brain telegraphs through certain nerves to the vocal apparatus, which then enunciates the thoughts in words appropriated to such ideas. The air around is stirred by the sound-waves into vibrating. The tremulous aerial agitation stirs similar vibrations in a metallic plate. These oscillations interrupt a magnetic current travelling fifty or a hundred miles along a wire. Then, at a distance of a hundred miles the interrupted current causes another metallic plate to vibrate in unison with the first plate; and now the air around the second plate, being set to vibrate by it, affects the ear of B, who is listening.* His auditory apparatus telegraphs to his brain, and so causes B to have ideas exactly corresponding with those of A, one hundred miles away. Now, not only is this the fact, but if other wires happen to be within a few feet of our first wire for a short distance anywhere along its extent, these wires may be so affected by induction that several other individuals, each scores of miles apart from each other, are, when listening, compelled to have ideas like to those that A and B have.

"We see, therefore, that even unbroken metallic communication is not at all necessary for the production of idea-inducing vibrations. This being so, let us remove the telephone and cease to employ the vocal apparatus. Merely let brain communicate with brain by means of etherial induction across air-occupied space, since we have found that one brain can communicate with others by etherial induction across air-occupied space between contiguous wires.* We have only to assume—and the assumption seems to me quite logical—that the molecularly-induced vibrations which must undoubtedly accompany brain action in the mind of A, and are communicated by it to the ether pervading its substance, are propagated to an unknown distance, doubtless to the ether pervading neighbouring brains, and then are able to set up in the brain of B similar molecular vibrations. If, then, these vibrations be intense enough, and B peculiarly sensitive and attentive for the nonce, they may be able to induce like action—*i.e.*, like ideas—in his mind, without the intervention of better and more accustomed modes of transfer. The alteration in the mode of transit seems to me to be somewhat analogous to leaping on board a steamer instead of using the gangway."

Something to the foregoing effect was what I wrote to Professor Barrett.

I also lately wrote to another man of science (a physicist) my notion on this subject, but he did not see his way to accepting it, and inquired, "What is the organ by which etherial waves affect the brain, and how are they conceived to act?" This, however, was asking too much, at least in the present stage of psychological physiology, which is only yet in its infancy. Indeed, some of our foremost men affirm that even on to hoary-headed old age it will

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* Where a plate of glass may be interposed.

As I said before, I refrain from quoting cases, but I beg to refer to a letter by Prof. Barrett, which appeared last July in *Nature*, vol. xxiv., page 212, for an excellent *résumé* of the subject. In that letter he says—"Attentive observation of these experiments led me to question the accuracy of that explanation of the phenomena with which Dr. Carpenter has made us familar—viz., unconscious muscular action on the one side and unconscious muscular discernment on the other. After making the most extravagant allowances for the existence, in some persons, of a muscular sense of preternatural acuteness, there still remained a large residuum of facts wholly unaccounted for on any received hypothesis. * * * A clergyman in Derbyshire has five young children, four girls and one boy, from 9 to 14 years of age, all of whom are able to go through the ordinary performances of the "willing game" rapidly and successfully, *without contact of hands or any communication besides the air between the person operating and the subject operated on.* * * * The father is found to be pre-eminently the best willer—to be in fact almost necessary for the success of the sensitive guesser [*i.e.*, mind-reader]. Further experiments showed that a battery of minds, all intently fixed on the same word, was far more successful than one or two alone. Apparently a *nervous induction* of the dominant idea in our minds took place in the passive mind of the child, and the experiment recalled the somewhat analogous phenomena of electric and magnetic induction. There seemed to be a veritable exoneural action of mind."

Some of those who are inclined to reject as utterly absurd the notion that ideas or representations of objects can be called up in the mind by the assistance of vibrations will please remember that persons born blind, who can tell the comparative sizes and shapes of objects in a room, can only do so from information sent them through nerve-conveyed vibrations. In fact, the like holds good in reference to sight. There are no such phenomena as coloured pictures of objects transmitted from eye to brain, to be kept there for future use; but merely pulsations or vibrations travelling inwards through infinitesimally minute tubuli containing material of the consistency of cream. Nay, more, any vibration-inducing disturbance affecting the optic nerve, such as pressing, cutting, or electric shocks, can induce colour to our consciousness, showing that the impingement of light-rays on the retina is not absolutely necessary for that purpose. Observe, however, that I imagine (as I mentioned in my paper on the Senses, vol. x., page 329) the retinal rods—conical and truncated—are of great service in defining shapes and sizes, as fingers are in touching for such purposes. The sense of colour and the sense of molar pressure are feelings compulsorily forced to have birth in us by the action of external entities, whereas the observation of shapes and sizes through means of seeing- and touching-work are our own operations, in which operations we employ contractile organs to aid us in gathering, selecting, and sorting feeling-information.

It may, at first sight, be thought that this view militates heavily against the notion that ideas or representations of objects can be conveyed by means of vibrations alone from brain to brain without the intervention of muscular assistance. A little reflection, however, will suffice to show that such an objection does not really hold good. Indeed, by means of symbols, in speech and writing, we are constantly getting ideas raised in our minds without needing to travel over the surfaces of the concrete objects, we, of course, having had like ideas previously in use. For example, if I say or write "A black dog is swimming after a white duck," ideas of shapes, sizes, colours, and operations immediately arise in our minds in consequence of vibrations that have no resemblance to any of these phenomena, habituated associations between the verbal symbols and mental operations being amply sufficient for the purpose.

Let us now, in conclusion, take as a basis to our hypothesis two accepted scientific inferences—(*a*) The existence of an all-permeating ether, whose modes of vibration induce the phenomena we call light, heat, electric and magnetic activities; (*b*) that all mental action is accompanied by decomposition of brain substance. I think these justify us in adopting as a corollary that all mental activity necessarily produces vibrations in the ether in and around acting brains, which vibrations must be propagated in all directions, even through contiguous brains, to a greater or less extent—the intensity decreasing as the square of the distance, other things equal, as aerial vibrations are propagated from a sounding instrument.

This being taken to represent, to a certain extent, the action and product of the person "willing," let us next consider what may be supposed to follow from the incidence of the vibrations on the brain of the individual operated on—the "mind-reader." That etherial vibrations do traverse such a brain may not be feasibly denied. Our skulls are not as dense as glass, which photal waves permeate, or as rock salt, that thermal vibrations travel through. Some persons are all but note-deaf, while others are precociously alive to musical vibrations. It may be objected that specialized passages are obviously necessary, since we have ears for the express purpose. I reply that most deaf mutes can keep better time to dance music than I can (who am note-deaf), the vibrations in their case being transmitted through ordinary body tissues. Remark further, that tuning-forks and tightened wires are set a-vibrating by the performance of a large orchestra in their neighbourhood, each fork and wire, according to its pitch, vibrating in consonance with some instrument of like pitch. Again, a skilled musician can, from a numerously-appointed orchestra, select and consciously follow the notes of any particular instrument. From these illustrations of analogous phenomena, we may conceive that a peculiarly-susceptible brain and individual can, by devoted attention, select and attend to the particular vibrations induced through the mental activity of the party acting the *rôle* of "willing." Hence results it that the brains act in unison and the thoughts are similar.*

Since I do not know of any equally probable explanation of the phenomena of mind-reading having yet been brought forward, I hope to be excused for bringing the foregoing before you. I acknowledge to having iterated considerably, but new views require iteration for their initial reception, not to speak of their formal recognition.

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* When the impassioned orator, his whole heart and soul glowing with emotion, sways the multitude with like emotions, I imagine it is often much more through the medium of intense mind-willing than the logical strength of his arguments that he does so. It does not seem to me improbable that Mr. Home could so far influence the minds of those in the room with him as to make them imagine that they saw anything he "willed" them to see. The instinctive insight occasionally manifested by children as to the sympathetic or unsympathetic nature of a visitor may to some extent be due to the agency assumed in the hypothesis.

Lastly, I should like to ask, May not such an agency be a powerful factor in the evolution of the "social organism?" And will the Kanto-Hegelian admit it to be a mode or medium by which he holds intercourse with the "world-consciousness?"

MINUTES OF SESSION.

11th May, 1881.[*]

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the New Buildings, 207 Bath Street—Dr. Wallace, President, in the Chair.

1. The Minutes of the last Meeting of the Society, having been printed in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairman.

2. The following were proposed as Members of the Society, viz.:—

Professor Jebb, LL.D., University of Glasgow. Recommended by Dr. Muirhead, Professor M'Kendrick, and Mr. John Mann.

George T. Beatson, M.D., 2 Royal Crescent. Recommended by Dr. Muirhead, Professor M'Kendrick, and Mr. John Mann.

Mr. James Smith, 7 Park Circus. Recommended by Dr. Muirhead, Professor M'Kendrick, and Mr. John Mann.

J. M'Gregor Robertson, M.A., M.B., Muirhead Demonstrator of Physiology, University of Glasgow. Recommended by Mr. John Mann, Dr. Muirhead, and Professor M'Kendrick.

Mr. John M. Cunningham, Manager of the Clydesdale Bank, Glasgow. Recommended by Mr. James L. Mitchell, Dr. Muirhead, and Professor M'Kendrick.

Mr. John B. Wingate, 7 Crown Terrace, Dowanhill. Recommended by Mr. James L. Mitchell, Mr. William Shaw, and Professor M'Kendrick.

Mr. William Pearce, Shipbuilder, 10 Park Terrace. Recommended by Mr. James L. Mitchell, Mr. William Shaw, and Professor M'Kendrick.

Mr. George Walker, Chemical Broker, 138 West George Street. Recommended by Dr. Andrew Fergus, Mr. John Mann, and Professor M'Kendrick.

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[*] Last Meeting of Session, 1880-81.

Mr. J. Watson Stuart, Writer, 88 St. Vincent Street. Recommended by Dr. Andrew Fergus, Dr. Muirhead, and Professor M'Kendrick.

Mr. Thomas Balmain, Banker, 1 Kew Terrace, Kelvinside. Recommended by Dr. Andrew Fergus, Dr. Muirhead, and Professor M'Kendrick.

Mr. Robert Gilchrist Finlay, Jun., Holmfield, Dalmuir. Recommended by Dr. Andrew Fergus, Mr. John Clark, and Mr. E. C. C. Stanford.

Mr. William Ogilvie, 1 Doune Terrace. Recommended by Mr. Archibald Robertson, Dr. Andrew Fergus, and Professor M'Kendrick.

Mr. George Miller, 1 Westbourne Gardens. Recommended by Dr. Andrew Fergus, Mr. John Mann, and Professor M'Kendrick.

Mr. Walter Duncan, East India Merchant, 9 Montgomerie Crescent. Recommended by Dr. Andrew Fergus, Mr. John Mann, and Professor M'Kendrick.

Mr. J. T. Anderson, Merchant, Westbourne Gardens. Recommended by Dr. Henry Muirhead, Professor M'Kendrick, and Mr. John Mann.

Dr. Yellowlees, Medical Superintendent, Gartnavel. Recommended by Dr. Henry Muirhead, Professor M'Kendrick, and Mr. John Mann.

Mr. J. Alexander Blackie, Publisher, 17 Stanhope Street. Recommended by Dr. Andrew Fergus, Dr. Muirhead, and Professor M'Kendrick.

Professor P. A. Simpson, M.D., University, 8 Brandon Place. Recommended by Dr. Andrew Fergus, Mr. John Mann, and Professor M'Kendrick.

Mr. Adam White, Sudbrooke, Pollokshields. Recommended by Dr. Andrew Fergus, Dr. Muirhead, and Professor M'Kendrick.

Dr. W. J. Brock, 2 Holyrood Crescent. Recommended by Dr. Andrew Fergus, Mr. John Mann, and Professor M'Kendrick.

Mr. J. Robertson Blackie, Publisher, 17 Stanhope Street. Recommended by Dr. Andrew Fergus, Dr. Muirhead, and Professor M'Kendrick.

Mr. John Hunt, Milton of Campsie. Recommended by Mr. David Sandeman, Mr. Archibald Robertson, and Professor M'Kendrick.

Mr. A. Erskine-Murray, Sheriff-Substitute of Lanarkshire, Sundown, Montgomerie Drive. Recommended by Mr. Thomas F. Muir, Professor M'Kendrick, and Dr. Muirhead.

Mr. John Young, Superintendent of Cleansing, 234 Parliamentary Road. Recommended by Mr. William R. W. Smith, Mr. J. J. Coleman, and Mr. John Mann.

3. Mr. John P. Craig read a paper on "The Cleansing of Cities, and the Utilization of Sewage," for which he received the thanks of the Society.

4. The Secretary read Reports from the various Sections of the Work done during the Session, and these Reports were adopted, and were ordered to be printed in the *Proceedings* of the Society.

(Signed) WILLIAM WALLACE.

2nd November, 1881.

The Philosophical Society of Glasgow held its first Meeting for Session 1881-2 on the evening of 2nd November, 1881, at eight o'clock, in the Rooms of the Society, 207 Bath Street—Dr. Wallace, President, in the Chair.

1. The Minutes of the last Meeting of the Society, having been printed in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairman.

2. The following were proposed for election as Members of the Society, viz.:—

Mr. Andrew Henderson Morgan, Actuary, 128 St. Vincent Street. Recommended by Mr. Archibald Hewat, Dr. Fergus, and Dr. Wallace.

Mr. W. J. Milligan, Writer, Laurel Bank, Partick. Recommended by Mr. Wallace Fairweather, Mr. B. H. Remmers, and Professor M'Kendrick.

Mr. Lindsay Burnett, Assoc. M.I.C.E., St. Kilda, Dowanhill. Recommended by Mr. John Mann, Dr. Muirhead, and Dr. M'Kendrick.

Mr. John Williamson, Engineer, 146 St. Vincent Street. Recommended by Mr. B. H. Remmers, Mr. John Mann, and Dr. Muirhead.

3. Dr. Wallace delivered an Opening Address on "The Dissociation of Chemical Compounds." Dr. Fergus moved, and Mr. James Mactear seconded, that a vote of thanks be given to Dr. Wallace for his interesting and able Address. The motion was carried by acclamation.

4. On the motion of the President, Mr. Archibald Hewat and Mr. George Watson were appointed Auditors of the Treasurer's Accounts for the past year.

5. Mr. Eben. Duncan gave notice of the following motion :—

"That the remit of the Society to the Sanitary Section to take measures towards the amendment of the Health of Scotland Act (1867) be continued for another year."

6. Mr. John Mayer gave notice of the following motion :—

"That Presidents of Sections should not be Members of Council unless these Sections are in actual operation, and hold meetings open to all Members of the Society."

7. The following gentlemen, who were balloted for as ordinary members, were declared duly elected :—Professor Jebb, Dr. George T. Beatson, Mr. James Smith, Mr. J. M'Gregor Robertson, M.B., Mr. John M. Cunningham, Mr. John B. Wingate, Mr. William Pearce, Mr. George Walker, Mr. J. Watson Stuart, Mr. Thomas Balmain, Mr. Robert Gilchrist, Mr. William Ogilvie, Mr. George Miller, Mr. Walter Duncan, Mr. J. T. Anderson, Dr. Yellowlees, Mr. J. Alexander Blackie, Professor P. A. Simpson, Mr. Adam White, Dr. W. J. Brock, Mr. J. Robertson Blackie, Mr. John Hunt, Sheriff Erskine-Murray, and Mr. John Young.

(Signed) WILLIAM WALLACE.

16*th November*, 1881.

The Eightieth Annual General Meeting of the Philosophical Society of Glasgow, for the Election of Office-bearers and other business, was held on the 16th of November, 1881, at eight p.m., in the Rooms of the Society, 207 Bath Street—Dr. William Wallace, President, in the Chair.

The Minutes of the last Meeting of the Society, having been printed in the circular calling this Meeting, were held as read, and were approved and signed by the Chairman.

2. The following were admitted as Members of the Society, viz.:—

Professor [illegible], [illegible], Mr George [illegible], Mr James Smith, [illegible] Professor [illegible], [illegible], Mr John M. Cunningham, Mr [illegible], Mr William Pearce, Mr George Walker, Mr [illegible], Mr Thomas [illegible], Mr Robert [illegible], [illegible], Mr William [illegible], Mr George Miller, Mr [illegible], Mr [illegible], Dr David [illegible], Mr [illegible], Professor [illegible] Simpson, M.D., Mr Adam [illegible], Mr [illegible], Mr [illegible] Baxter, Mr John [illegible], [illegible], and Mr John Young.

The following were proposed as Members, viz.:—

Mr W. [illegible] Wilson, [illegible] Street. Recommended by Mr John [illegible], Professor M'Kendrick, and Mr J. J. [illegible].

Mr James Wilson, Accountant, [illegible] West Regent Street. Recommended by Mr David [illegible], Mr John [illegible], and Mr [illegible].

Mr James [illegible], Civil Engineer, [illegible] Wellington Street. Recommended by Mr John L. Bruce, Mr Robert Leggat, and Mr Robert [illegible].

Mr David [illegible], C.A., [illegible] West Regent Street. Recommended by Mr John L. Bruce, Mr Robert Leggat, and Mr Robert [illegible].

Mr J. B. Cunningham, Jun., Merchant, 4 Derby Crescent, [illegible]. Recommended by Dr William Wallace, Mr John [illegible], and Mr Thomas Muir.

Mr [illegible], [illegible] Terrace, Hillhead. Recommended by Mr J. B. [illegible], Mr W. J. [illegible], and Dr Edmund J. Mills.

Dr John Kerr, M.A., Inspector of Schools. Recommended by Mr Thomas Muir, Professor Jack, and Professor M'Kendrick.

3. Professor M'Kendrick, Secretary, read the Annual Report by the Council on the State of the Society, which was adopted.

and ordered to be printed in the *Proceedings.* The Report was as follows:—

REPORT ON THE STATE OF THE SOCIETY BY THE COUNCIL FOR THE SESSION 1880-81.

I. *Membership.*—The number of Members on the Roll at the beginning of Session 1880-81 was 636; during the Session 74 were added, 3 were reinstated from the Suspense List, making 713 in all. Of this number 17 have resigned, 7 have left Glasgow—their names being placed on the Suspense List,—9 have died, 1 was elected an Honorary Member, and 9 have been struck off the Roll for non-payment of annual subscriptions; leaving on the Roll, at the beginning of the present Session, 670 Members, being an increase of 34. Of the 74 new entrants, 10 became Life Members. There are 20 Honorary Members, consisting of 6 Foreign, 3 American and Colonial, and 11 British. The corresponding Members are 4 in number. There are 35 Life Members.

II. *Sections.*—The Meetings of the Sections have been well attended, and, in addition to many papers read at these Meetings, important communications have been transmitted to the Society, some of which appear in the *Proceedings.*

III. *The Proceedings.*—The printed *Proceedings* of the Society for 1880-81 embrace 19 papers and 10 plates, and they will be found to contain some substantial contributions to science.

IV. *The Gas Exhibition.*—The Council regret that, from various causes of delay, a Report has not yet been received from the Committee having charge of the Gas Exhibition. It is desirable that the matters of the Gas Exhibition should be wound up without further delay, and the Council hope soon to lay the Report or Reports before the Society.

V. *New Buildings.*—The new rooms have been found very convenient and well suited for the purposes of the Society and of its Sections. They have also been taken advantage of by the Geological and Archæological Societies and others, on terms satisfactory to this Society and to the Institution of Engineers and Shipbuilders.

By order of the Council.

(Signed) JOHN G. M'KENDRICK,
Secretary.

5. The Audited Statement of Accounts for Session 1880-81, by Mr. John Mann, the Treasurer, having been printed in the circular calling the Meeting, was held as read, was approved of, and was ordered to be printed in the *Proceedings.* A vote of thanks to the Treasurer was carried unanimously.

Dr. ABSTRACT OF TREASURER'S

1881.—Oct. 31.

To Entry-money from 74 New Members, at 21s.,		£77 14 0	
„ Annual Dues from 2 Members for 1878-79, at 21s.,	£2 2 0		
„ Annual Dues from 7 Members for 1879-80, at 21s.,	7 7 0		
„ Annual Dues from 580 Ordinary Members for 1880-81, at 21s.,	609 0 0		
„ Annual Dues from 62 New Members for 1880-81, at 21s.,	65 2 0		
		683 11 0	
„ Life Subscription from 12 New Members, at £10 10s.,		126 0 0	
			£887 5 0
„ CHEMICAL SECTION—			
1 Associate for 1877-78, at 5s.,		£0 5 0	
1 do. 1878-79, at 5s.,		0 5 0	
4 do. 1879-80, at 5s.,		1 0 0	
36 do. 1880-81, at 5s.,		9 0 0	
			10 10 0
ARCHITECTURAL SECTION—			
78 Associate Fees between 2nd Nov., 1878, and 18th March, 1881, at 5s.,			19 10 0
„ Corporation of Glasgow, Interest on "Exhibition Fund" for year to Whitsunday, 1881—less Income Tax,			48 15 0
„ Proceedings, &c., sold,			2 1 2
„ BATH STREET JOINT BUILDINGS—			
Society's half of Balance of £3,000 Bond,			600 0 0
„ LOANS TO SOCIETY—			
Sums of £200 and £300,			500 0 0
„ Balance due Treasurer,			109 9 11
			£2,177 11 1

GLASGOW, 22d November, 1881.—We, the Auditors appointed by the examined the same, of which the above is an Abstract, and have found them One Hundred and Nine Pounds Nine Shillings and Elevenpence.

Memo. by Treasurer.—The Amount of the Society's Funds invested in half of Bond, £1,500, and the above Loans of £500 = £1,355.—J. M.

ACCOUNT—SESSION 1880-81. **Cr.**

1880.—Nov. 1.		
By Balance due Treasurer from last Session, ...		£18 3 6½
1881.—Oct. 31.		
By Salary to Secretary, ...	£75 0 0	
,, Allowance for Treasurer's Clerks, . .	15 0 0	
		90 0 0
,, New Books, Periodicals, and Foreign Periodicals, ...	£114 4 4½	
,, Printing Circulars, *Proceedings*, &c., 1879-80, £191 10s.; 1880-81, £142 10s. 3d., .	334 0 3	
,, Binding, ...	24 19 0	
,, Lithographs for *Proceedings*, &c., . .	65 6 0	
,, Postage and Delivery of Circulars, Letters, and Parcels, ...	35 12 1	
,, Stationery, ...	7 18 0	
	£581 19 8½	
Less, Contributions by Authors to cost of Illustrations, ...	11 5 8	
		570 14 0½
,, Fire Insurance on Library for £5,400, .	£4 0 6	
,, Furnishings and Repairs, ...	15 18 3	
,, Postages, &c.—per Treasurer, £2 4s. 3d.; per Secretary, £5 12s. 8d., . .	7 16 11	
,, Sundries in Library, ...	1 8 11	
,, Interest on Loans, ...	9 15 6	
		39 0 1
,, SUBSCRIPTIONS TO SOCIETIES—		
Ray Society, 1881, ...	£1 1 0	
Palæontographical Society, 1881, . .	1 1 0	
		2 2 0
,, CHEMICAL SECTION—		
Expenses per Treasurer of Section, ...		9 18 11
,, ARCHITECTURAL SECTION—		
Expenses per Treasurer of Section, ...		10 2 8
,, BATH STREET JOINT BUILDINGS—		
Society's half of Balance of Tradesmen's Accounts, .		1,280 0 0
,, JOINT EXPENSES OF ROOMS—		
Society's half of Interest on Bond, Taxes, Cleaning, Lighting, and Heating, Salaries of Sub-Librarian and Assistant—less half of Revenue from Letting, .		157 9 10
		£2,177 11 1

Society to examine the Treasurer's Accounts, for the year 1880-81, have correct, the Balance due to the Treasurer at 31st October last being

the Bath Street Joint Buildings up to 31st October, 1881, is £3,355, less

(Signed) ARCH. HEWAT.
GEORGE WATSON.

[illegible]

[illegible] Mr. David [illegible] elected one of the Vice- [illegible] Dr Henry Muirhead, who [illegible] by Mr. John Mayer, and

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INLAND MARINE DEPARTMENT

seconded by Mr. John Jex Long, that Mr. James Mactear, F.C.S., be elected to the office. Dr. Eben. Duncan and Mr. W. J. A. Donald having been appointed scrutineers, the Society took a vote by ballot, when it was found that there were 43 votes for Mr. Mactear and 40 votes for Professor Gairdner. Mr. Mactear was accordingly declared to be duly elected to the office of Vice-President for a term of three years from this date.

(2) On the motion of the Chairman, Mr. John Robertson was unanimously re-elected Librarian for the present year.

(3) On the motion of the Chairman, Mr. John Mann was unanimously re-elected Treasurer for the present year.

(4) On the motion of the Chairman, Professor M'Kendrick was unanimously re-elected Secretary for the present year.

(5) The Chairman stated that six new Members of Council were required, in room of Mr. Archibald Robertson, Mr. J. J. Coleman, Dr. M'Vail, and Mr. John Kirsop, who retire by rotation, and of Mr. Robert R. Tatlock and Mr. David Mackinlay, who had resigned office. The thanks of the Society were awarded to these gentlemen, and in particular to Mr. Archibald Robertson, for the great trouble he had taken in connection with the erection of the new buildings.

It was moved by Mr. Archibald Robertson, and seconded by Mr. Coleman, that the following gentlemen be elected Members of Council, viz.:—Mr. James Paton, F.L.S.; Mr. James Thomson, F.G.S., Professor Jack, LL.D.; Mr. Alexander Scott, Mr. J. T. Bottomley, M.A.; and Dr. W. J. Fleming. Mr. Robert R. Tatlock moved, and Dr. Brock seconded, Mr. Andrew Jamieson, C.E., as a Member of Council. Mr. Sigismund Schuman proposed, and Dr. Morton seconded, Mr. Archibald Hewat, F.F.A., F.S.S., as a Member of Council. Mr. John Mayer, F.C.S., proposed, and Mr. D. M. Nelson seconded, Mr. Hazelton R. Robson as a Member of Council.

The Society then balloted for six Members of Council, Dr. Morton and Mr. D. M. Nelson having been appointed scrutineers, with Mr. James L. Mitchell as oversman. The scrutineers reported that the following had the greatest number of votes:—Mr. James Thomson, 67; Mr. James Paton, 65; Mr. Alexander Scott, 52; Dr. W. J. Fleming, 47; Mr. Hazelton R. Robson, 46; and Pro-

[illegible]. These gentlemen were therefore declared by the Chairman to have been duly elected Members of Council.

7. Mr. Andrew Jamieson, C.E., Principal of the College of Science and Arts, read a paper "On the Connections used in testing Incandescent Lamps." The paper was illustrated by diagrams and tables, and by specimens of the different incandescent lamps now introduced for electric lighting. Mr. Jamieson received the thanks of the Society for his paper.

8. Professor M'Kendrick read an Obituary Notice of the late Dr. David Foulis, which was ordered to be printed in the Proceedings.

9. Dr. Eben. Duncan then moved—

"That the remit of the Society to the Sanitary Section to take measures towards the amendment of the Health of Scotland Act 1867 be continued for another year."

The motion was unanimously adopted.

10. Mr. John Mayer, F.C.S., then moved—

"That Presidents of Sections should not be Members of Council of the Society unless these Sections are in actual operation, and hold meetings open to all Members of the Society."

The motion was seconded by Mr. John Jex Long. After some discussion, the motion was put to the vote, and was negatived by a large majority.

11. The following gentlemen, who were balloted for as Ordinary Members, were declared duly elected:—Mr. Andrew Henderson Morton; Mr. W. J. Milligan; Mr. Lindsay Burnet; and Mr. John Williamson.

(Signed) WILLIAM WALLACE.

30th November, 1881.—Dr. Wm. Wallace *in the Chair.*

1. The Minutes of the last Meeting of the Society, having been printed in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairman.

2. The following new Members were admitted:—

Mr. Andrew Henderson Morgan, Mr. W. J. Milligan, Mr. Lindsay Burnet, Mr. John Williamson.

3. The following were proposed for election as Members of the Society, viz.:—

Mr. John M'Nab, of the Flemington Coal Company (Limited), 79 West Nile Street. Recommended by Mr. David Thomson, I.A., F.R.I.B.A., Mr. A. Lindsay Miller, and Mr. John Mann, C.A.

Mr. William G. O'Beirne, Analytical Chemist, South-Western Hotel, Renfrew. Recommended by Mr. Edward C. C. Stanford, F.C.S., Mr. J. J. Coleman, F.C.S., and John Clark, Ph.D., F.C.S.

Mr. W. S. Woodburn, L.D.S., Lecturer on Mechanical Dentistry, Anderson's College, 17 Carlton Place. Recommended by Mr. Thomas G. Holt, Mr. Charles Wilson, and Mr. Thomas S. Cree.

4. Dr. James B. Russell, late President of the Sanitary and Social Economy Section, and Medical Officer of Health for Glasgow, read a paper "On the Decade of 1871-80 in Glasgow—a Sanitary Retrospect," for which he received the thanks of the Society.

5. The Secretary read a "Report by Dr. Henry Muirhead, one of the Delegates of the Society to the Gathering of Delegates from other Societies attending the Meeting of the British Association at York in August last," which had been postponed from last Meeting. On the motion of Mr. John Mayer, F.C.S., Dr. Muirhead was thanked by the Society, the Report was approved of, and was remitted to the Council for publication in the *Proceedings.*

6. A demonstration was given by J. M'Gregor Robertson, M.A., M.B., Muirhead Demonstrator of Physiology in the University of Glasgow, of "A Mode of directly Observing the Work done by Frog's Muscle," for which he received the thanks of the Society.

7. The following gentlemen, who were balloted for as Ordinary Members, were declared duly elected:—Mr. W. E. Wilson, Mr. James Wilson, Mr. James [illegible], Mr. David [illegible], Mr. J. R. [illegible], Mr. [illegible] [illegible], and Mr. John [illegible].

Signed, WILLIAM THOMSON,
Per WILLIAM WALLACE.

ABSTRACT STATEMENT of the THOMAS GRAHAM MEDAL AND
LECTURE FUND — Session [illegible].

[illegible] [illegible] [illegible] Treasurer, Mr. John Clark, and Mr. E. G. Shaw.

To [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Glasgow and South-Western Railway Company,	£[illegible] [illegible] [illegible]	By Do.	£[illegible] [illegible] [illegible]
[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] Union Bank of Scotland,	[illegible]	Balance,	[illegible] [illegible] [illegible]
[illegible] in Treasurer's hands,	[illegible]		
[illegible] of [illegible] [illegible] E. R. [illegible],	[illegible]		
	£[illegible] [illegible] [illegible]		£[illegible] 1 6

Signed, J. J. COLEMAN, Treasurer.
JOHN CLARK,
E. G. SHAW, } Auditors.

[illegible] December, [illegible]

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the Rooms of the Society, 207 Bath Street—Sir William Thomson, Honorary Vice-President, in the Chair.

1. The Minutes of the last Meeting of the Society, having been printed in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairman, after the following

addition had been made to them on the suggestion of Dr. A. K. Irvine:—"Mr. Campbell Douglas asked if the attention of the Council had been directed to the charges made in the public newspapers as to the relation of Dr. Wallace, the President, to the recent Gas Exhibition. After some remarks by Dr. A. K. Irvine and others, Mr. Nathaniel Dunlop informally replied that the Council had the matter in view, and would be ready with their opinion at the proper time."

2. The following new Members were admitted:—

Mr. W. H. Wilson, Mr. James Wilson, Mr. James Elder, Mr. David Sturrock, Mr. J. R. Cunningham, Jun.; Mr. Louis Campbell.

3. The following were proposed for election as Members of the Society, viz.:—

Mr. James C. Stevens, Clerk, 10 South Portland Street. Recommended by Mr. John Jex Long, Dr. Wallace, and Mr. John Laird.

Mr. Alexander G. Muir, Clerk, 6 Regent Park Terrace, Strathbungo. Recommended by Mr. John Jex Long, Dr. Wallace, and Mr. John Laird.

Mr. Arthur Wingate, 6 Kelvin Drive. Recommended by Professor Ferguson, Dr. James J. Dobbie, and Professor M'Kendrick.

4. The Chairman read the following communication from the Council of the Society:—

"The Council of the Philosophical Society of Glasgow met in the Council Room, in the Rooms of the Society, on Wednesday, the 7th of December, 1881. Present—Sir William Thomson (in the Chair), Dr. Wallace, Mr. Michael Connal, Professor Grant, Mr. Thomas Muir, Dr. Fergus, Mr. John Mann, Mr. E. C. C. Stanford, Mr. Alexander Scott, Mr. Nathaniel Dunlop, Dr. W. J. Fleming, Dr. Neil Carmichael, Mr. John Robertson, Dr. Stirton, Mr. J. Jex Long, Mr. Hazelton R. Robson, Mr. James Sellars, Jun., and Professor M'Kendrick.

"A statement was submitted to the Meeting by Dr. Wallace in relation to certain allegations by Mr. St. John Vincent Day and others in the public newspapers respecting the part Dr. Wallace took as a Juror in the recent Exhibition of Gas and Electricity. The Council discussed the matter most carefully, and came unanimously to the resolution that all the charges made in these letters are without foundation, and that Dr. Wallace had carried [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] to the guidance of Juror[illegible] [illegible] Executive Committee. It was resolved that this resolution be read [illegible] [illegible] at the next ordinary Meeting of the Society.

(Signed) WILLIAM THOMSON.

Dr. [illegible] Cameron, M.D., read a paper "On Microbes in their relation to Fermentation, Putrefaction, and Disease." After some discussion, in which Dr. John [illegible], Professor George Buchanan, [illegible] [illegible], Dr. [illegible], Dr. Morton, the President, and Dr. [illegible] took part, a hearty vote of thanks was given to Dr. [illegible] for his interesting paper, which was illustrated by diagrams and by a microscopical demonstration of some of the [illegible] [illegible].

Dr. [illegible] Irvine gave notice that at the next ordinary Meeting of the Society he would move as follows:—"That Dr. Wallace [illegible] [illegible] the Chair of this Society till the charges against him [illegible] [illegible]."

Mr. [illegible] gave notice that in the event of Dr. Irvine's [illegible] [illegible] he would move the previous question.

Mr. J. A. Nelson gave notice that at the next ordinary Meeting of the Society he would move as follows:—"That the [illegible] question arising from the actions of the Executive of the [illegible] [illegible] be remitted to the General Committee to be [illegible]."

The following gentlemen, who were balloted for as Ordinary Members, were declared duly elected:—

Mr. [illegible] A. Nai[illegible], Mr. William G. O'Beirne, and Mr. W. S. [illegible].

Before Dr. Irvine gave notice of Motion at last Meeting he asked the following question:—"I should like to be informed if Dr. Wallace has temporarily or permanently vacated the Chair, as it might relieve me of a painful duty." No answer to this question having been given, Dr. Irvine then gave notice of his motion.

(Signed) WILLIAM WALLACE
for WILLIAM THOMSON.

4th January, 1882.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the Rooms of the Society, 207 Bath Street—Dr. William Wallace, President, in the Chair.

1. The Minutes of the last Meeting of the Society, having been printed in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairman, after the following addition had been made to them on the suggestion of Dr. A. K. Irvine:—"Before Dr. Irvine gave notice of motion at last Meeting "he asked the following question:—I should like to be informed "if Dr. Wallace has temporarily or permanently vacated the chair, "as it might relieve me from a painful duty? No answer to this "question having been given, Dr. Irvine then gave notice of his "motion."

2. The following new Members were admitted:—

Mr. John M'Nab, Mr. William G. O'Beirne, Mr. W. S. Woodburn.

3. The following were proposed as Members of the Society:—

Mr. Daniel Macmillan, F.E.I.S., 26 Ashton Terrace. Recommended by Professor M'Kendrick, Mr. Archibald Robertson, and Mr. John Kirsop.

Mr. Arthur T. Scott, M.A., 4 Dixon Street. Recommended by Mr. Archibald Robertson, Mr. John Kirsop, and Professor M'Kendrick.

4. A paper was read by Mr. F. J. Rowan, on behalf of M. Bidard, of Rouen, "On the Structure of the Flower and Fertilizing Organs of Wheat," for which Mr. Rowan was thanked by the Society. The paper was illustrated by photographs thrown on the screen.

5. Mr. H. F. Alexander read a paper "On an Improved Barometer."

6. Mr. George Stuart read a description of, and exhibited, "A new Float and Life Preserver."

7. Dr. Wallace having vacated the chair, called on Sir William Thomson to preside during the remainder of the Meeting. Sir William Thomson took the chair accordingly.

8. Sir William Thomson called the attention of the Society to an advertisement by Messrs. W. & B. Cowan, Buccleuch Street, Edinburgh, in the Journal of Gas Lighting, No. [illegible], of date January [illegible], stating that the highest award at the Philosophical Society's Exhibition in Glasgow, 1880, had been given to a [illegible] Standard Gas Holder. Sir William Thomson stated that, as the Council had been informed that no such award had been given, they were determined to put a stop to all such advertisements by Messrs. W. & B. Cowan.

9. Dr. Wallace read a statement to the Society, dealing with certain allegations made respecting the part he took as a Juror in the recent Exhibition of Gas and Electricity.

10. Dr. [illegible] Irvine moved—"That Dr. Wallace do not occupy the chair of this Society till the charges against him have been refuted." The motion was seconded by Dr. [illegible].

11. Mr. W. P. Buchan moved, in room of Mr. John Mayer, and Mr. Sigismund Schuman seconded, an amendment of the previous question.

12. Mr. D. M. Nelson departed from his announced motion and moved, and Mr. J. J. Coleman seconded, a motion to the effect that consideration of the whole question be deferred until the Report of the Executive Committee of the Gas Exhibition be submitted to the Philosophical Society.

13. After considerable discussion, on the suggestion of Sir William Thomson, Dr. Irvine withdrew his motion, the amendment of the previous question was dropped, and Mr. D. M. Nelson also withdrew his motion. It was then unanimously resolved, also on the suggestion of the Chairman, to remit the whole matter in dispute back to the Council for reconsideration, on the understanding that the Council would report to the Society.

14. The following gentlemen, who were balloted for as Ordinary Members, were declared duly elected:—Mr. James C. Stevens,

Clerk, 10 South Portland Street; Mr. Alexander G. Muir, Clerk, 6 Regent Park Terrace, Strathbungo; and Mr. Arthur Wingate, 6 Kelvin Drive.

(Signed) WILLIAM WALLACE.

18th January, 1882.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the Rooms of the Society, 207 Bath Street—Dr. William Wallace, President, in the Chair.

1. The Minutes of the last Meeting of the Society, having been printed in the notice calling this Meeting, were held as read, and were confirmed and signed by the Chairman.

2. Mr. J. Law Crawford, Solicitor, 196 St. Vincent Street, Glasgow, was recommended as a Candidate for the Membership of the Society by Mr. Wallace Fairweather, C.E., Mr. John Mann, C.A., and Dr. M'Kendrick.

3. A paper was read by Dr. J. M'Gregor Robertson, M.A., Muirhead Demonstrator of Physiology in the University of Glasgow, entitled "An Account of the Present State of Animal Electricity." The paper was illustrated by diagrams and experiments; and, after a few remarks by Principal Jamieson, Dr. Andrew Buchanan, and others, a cordial vote of thanks was awarded to Dr. M'Gregor Robertson.

4. The following gentlemen, who were balloted for as Ordinary Members, were declared duly elected:—

Mr. Arthur T. Scott and Mr. Daniel Macmillan.

(Signed) WILLIAM WALLACE.

1st February, 1882.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the Rooms of the Society, 207 Bath Street—Dr. William Wallace, President, in the Chair.

1. The Minutes of the last Meeting of the Society, having been

[illegible] the [illegible] calling this Meeting, were held as read, and were [illegible] signed by the Chairman. After the [illegible] of [illegible] by Dr. [illegible] who [illegible] the Minutes on the ground [illegible] by the Secretary the [illegible]. In reply to a question by [illegible] the Secretary stated that matters relating to the [illegible] were [illegible] communicated by the Council, and that in [illegible] would be given until all the Jurors' reports had been sent to the Council by the Executive Committee of the [illegible] Exhibition.

[illegible] proceeded to address the Meeting with reference to the matter [illegible] the question above alluded to, it was moved by Dr. [illegible] and seconded by Mr. W. Eason, that Dr. [illegible] be not heard. As an amendment, that he be heard [illegible] was moved by Dr. [illegible], and seconded by Dr. [illegible]. On the vote being taken, three Members [illegible] for the amendment and twenty-three for the motion. The Chairman declared that the motion had been carried.

The following were proposed as Members of the Society:—

Mr. [illegible] Brown, [illegible], [illegible] Jamaica Street. Recommended by Mr. John Farquhar, Mr. [illegible] Robertson, and Mr. Robert [illegible] Brown, [illegible]

Mr. Joseph [illegible], [illegible] West George Street. Recommended by Mr. [illegible] Hays, Mr. Robert R. Tatlock, F.R.S.E., &c., and Dr. John Clark, [illegible], &c.

Mr. William M[illegible], Drysalter, Woodneuk, Barrhead. Recommended by Mr. [illegible] Hays, Mr. Robert R. Tatlock, F.R.S.E., &c., and Dr. John Clark, F.I.C., &c.

4. A paper was read by Dr. John C. M'Vail, Kilmarnock (communicated from the Biological Section), entitled "History of Small-pox in Kilmarnock during last Century." After some discussion, in which Dr. Fergus, Dr. Russell, Dr. Stirton, and others took part, Dr. M'Vail received a cordial vote of thanks for his paper, and the feeling of the Meeting was strongly expressed in favour of its publication in the *Proceedings* of the Society.

5. A paper was read by Mr. Alfred R. Bennett, Member of

the Society of Telegraph Engineers and of Electricians, entitled "A Cheap Form of Voltaic Battery." Mr. Bennett exhibited the battery, and illustrated its value by various experiments, and he received a cordial vote of thanks.

6. The President announced that Mr. J. Law Crawford, Solicitor, 196 St. Vincent Street, Glasgow, had been elected a Member of the Society.

7. Dr. Fergus moved—"That the Herbarium in possession of the Society be presented to the Museum in Kelvingrove Park." After some discussion, the matter was remitted to the Council, with instructions to carry out the transfer, provided there was no legal impediment.

8. Mr. John Mayer, F.C.S., gave notice that he would move, at next ordinary Meeting—"That it be remitted to the Council to arrange for Reports of Discussions on Papers communicated to the Society being prepared for publication in the *Proceedings*, along with the papers themselves."

9. Dr. A. K. Irvine gave notice that he would move, at next ordinary Meeting—(1) "As the Council has postponed its Report on matters connected with the charges against Dr. Wallace, *sine die*, that Dr. Wallace do not occupy the Chair of the Society till the Report of the Council has been presented to the Society." (2) "That, as Dr. Wallace has apologised to Dr. Glover and Mr. Day, it behoves him, without delay, to do the same to the Society for the injury and insult put upon it by him."

10. Mr. Alex. Whitelaw gave notice that he would move, at next ordinary Meeting—"That the Members of this Society do mark their appreciation of Dr. Wallace's merits as a Member, and their faith in him as an honourable man, by a vote of confidence."

(Signed) WILLIAM WALLACE.

15th February, 1882.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the Rooms of the Society, 207 Bath Street—Dr. William Wallace, President, in the Chair.

1. The Minutes of the last Meeting of the Society having been

[illegible]

[illegible] Dr. John [illegible]

[illegible] Mr. W. Thomson [illegible] Dr. [illegible] Thomson [illegible]

[illegible] Dr. Thomas [illegible]

[illegible]

[illegible] Mr. Wallace [illegible] Mr. St. John [illegible] Mr. Wallace [illegible] Exhibition [illegible] The Council [illegible] Mr. Wallace [illegible] Mr. Wallace had acted [illegible] in every particular the instructions laid down for the guidance of Jurors by the Executive Committee.

[illegible] *Minutes of Council of the 11th February, 1852.*—Sir William [illegible] having brought before the Council a communication from the agents of Messrs. [illegible]—challenging the accuracy of a statement made by him as Chairman of the Meeting of the Society of the 4th January—it was explained that it appeared that the Executive Committee of the late Exhibition had agreed that the awards to be issued to an exhibitor should apply either to the group of articles exhibited in any Section by him, or to a single article of the group; and that the Secretary to the Exhibition, Mr. Mann, was under the conviction that no separate [illegible]tificates had been given for each separate article exhibited by Messrs. [illegible] & E. Cowan. After full inquiry, however, it has been ascertained [illegible] three separate cards, bearing his initials and the printed words

'Highest Award,' had been issued by the Secretary, with Dr. Wallace's approval; and, to this extent, the statement made to the Council, upon the authority of which Sir William Thomson had spoken on 4th January, 1882, was inaccurate.

"It was explained by Dr. Wallace that a letter was addressed by him to Messrs. W. & B. Cowan, on 19th November, 1880, shortly after the close of the Exhibition, informing these gentlemen that it had been decided by the Executive Committee, that only one award could be given to each exhibitor in any Section, the award to consist of a handsome Medal; and Messrs. Cowan were invited to elect whether to receive the Medal for their group of Three Exhibits, or for the 'Warner and Cowan Meter,' which was one of them, by itself—on the understanding that, if they adopted the latter alternative, they could have no award for the other two articles, namely—the 'Dry Meter,' and the 'Standard Gas-Holder.' Messrs. Cowan not having expressed any preference, the Jurors decided independently, and issued a Medal to Messrs. Cowan for their 'Warner and Cowan Meter,' accompanied by a duly-signed Certificate that such a Medal had been awarded for their 'Warner and Cowan Wet Meter,' and that Medal and Certificate are now in their possession."

6. The motion standing in the name of Mr. John Mayer was, at his suggestion and to facilitate business, postponed till next Meeting.

7. It was moved by Dr. A. K. Irvine, and seconded by Dr. J. A. Lothian, as follows:—"As the Council has postponed its Report on matters connected with the charges against Dr. Wallace, *sine die*, that Dr. Wallace do not occupy the Chair of the Society till the Report of the Council has been presented to the Society." Mr. W. P. Buchan moved, and Mr. John Mayer seconded, the "Previous Question." On a vote being taken, 76 Members voted for the "Previous Question," and two for the motion. The Chairman declared that the "Previous Question" had been carried.

8. The second motion standing in Dr. Irvine's name was, by leave, withdrawn.

9. It was moved by Mr. Alexander Whitelaw, seconded by Mr. Nathaniel Dunlop, and carried by acclamation, as follows:—"That the Members of this Society do mark their appreciation of Dr. Wallace's merits as a Member, and their faith in him as an honourable man, by a vote of confidence."

10. The following gentlemen were declared by the Chairman to have been duly elected Members of the Society:—Mr. Robert

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible] Wallace [illegible]

[illegible] a new Family [illegible] The paper was illus- [illegible] which [illegible] Mr. Thomson [illegible] of the Society.

[illegible] of Physiology [illegible] exhibited a method of [illegible] and showed the [illegible] He received the thanks of the Society.

6. Mr. James Harley was declared by the Chairman to have been duly elected a Member of the Society.

7. The motion standing in the name of Mr. John Mayer was modified, on the suggestion of Dr. Fergus, as follows:—"That it be remitted to the Council to consider the expediency of arranging for Reports of Discussions on Papers communicated to the Society being prepared for publication in the *Proceedings*, along with the Papers themselves." In this modified form the Resolution was moved by Mr. Mayer, seconded by Dr. Fergus, and unanimously adopted.

(Signed) THOMAS MUIR,
For WILLIAM WALLACE.

15*th March*, 1882.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the Rooms of the Society, 207 Bath Street—Mr. Thomas Muir, M.A., &c., Vice-President, in the Chair.

1. At the request of Dr. A. K. Irvine, the Minutes were read by the Secretary. On the suggestion of Dr. A. K. Irvine, the first paragraph was amended to read thus:—"At the request of Dr. A. K. Irvine, a portion of the Minutes was read by the Secretary. Dr. A. K. Irvine having pointed out that a portion of the Minutes had been read at a former Meeting, it was moved by Mr. John Mayer, and seconded by Dr. Henry Muirhead, that the Minutes be adopted as they were printed in the billet calling this Meeting. This motion was carried by acclamation, and the Minutes were accordingly confirmed and signed by the Chairman." The Minutes, so amended, were confirmed and signed by the Vice-President in the Chair.

2. Mr. John Young, Analytical Chemist, Blackhill House, Cumbernauld Road, was recommended for the Membership of the Society by Mr. W. Craig-Ramsay, Writer, Dr. Wallace, and Dr. John Clark.

3. Mr. Robert Corbet, 168 New City Road, exhibited and described a Compound Pendulum Apparatus for drawing Harmonic Curves, the distinctive feature of which was the movement

by clockwork of a horizontal table carrying the plate on which the curves were described. Examples of the curves were projected on the screen. Mr. Corbet received the thanks of the Society.

4. Mr. William Kennedy, Braemar Villa, Pollokshields, was declared by the Chairman to have been duly elected a Member of the Society.

(Signed) WILLIAM WALLACE.

29th March, 1882.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the Rooms of the Society, 207 Bath Street—Dr. William Wallace, President, in the Chair.

1. The Minutes of last Meeting, having been printed in the notice calling this Meeting, were held as read, and on the motion of Mr. J. J. Coleman, seconded by Mr. Ramsay, were adopted. They were signed by the Chairman.

2. A paper was read "On a Proposed General Method for the Solution of Equations," by Thomas Muir, Esq., M.A., F.R.S.E., &c., Vice-President of the Society. Mr. Muir received the thanks of the Society.

3. A paper was read, giving "An Account of some Physico-Chemical Investigations," by James B. Hannay, Esq., F.R.S.E., F.C.S., &c. Mr. Hannay received the thanks of the Society.

4. The Chairman announced that Mr. John Young M'Lellan had been duly elected a Member of the Society.

5. The Secretary reported, in reply to the interrogations of Dr. Andrew Buchanan and Mr. John Mayer, made at last Meeting, that the Council had presented the Herbarium in possession of the Society to the Museum in Kelvingrove Park, in accordance with the instructions to the Council contained in the Minute of Meeting of 1st February. He read a statement regarding the origin of the Herbarium made to the Council by Mr. Michael Connal, Mr. John Alexander, and Mr. Robert Balloch, the only surviving Members of the Botanical Section of the Society, and engrossed in

Minutes of Council, p. 138, and he also read a letter, dated 28th March, 1882, addressed to the President and Council by Mr. John Alexander, placing the Herbarium and the sum of £5 18s. 2d. at the disposal of the Society.

6. The Secretary stated, in reply to an interrogation by Dr. Irvine, that the Council had resolved not to interfere in the question at issue between him and Mr. John Mann.

7. Dr. A. K. Irvine read to the Meeting a letter he had addressed to Dr. M'Kendrick, dated 18th March, 1882.

8. Dr. Irvine gave notice of the following motion:—"That the Society disapprove of an Official making offensive motions in reference to Members."

9. Mr. John Mann gave notice of the following motion:—"That the following be added to the Articles of the Society, viz.:—'That it shall be competent, by the vote of three-fourths of the Members present at two successive Ordinary Meetings, on due notice of motion to that effect, to expel any Member who, in the opinion of such Meetings, has conducted himself in such a manner as to be injurious to the character and interests of the Society.'"

(Signed) WILLIAM WALLACE.

8th April, 1882.

The Philosophical Society of Glasgow met this evening, at eight o'clock, in the Rooms of the Society, 207 Bath Street—Dr. William Wallace, President, in the Chair.

1. The Minutes of last Meeting, having been printed in the notice calling this Meeting, were held as read, and were approved of and signed by the Chairman.

2. Dr. Henry Muirhead read a paper "On the Mode of Mental Inter-communication in Thought-willing and Thought-reading," for which he received the thanks of the Society.

1. Dr. John Dougall read an “Account of an Examination of a [illegible] [illegible],” for which he received the thanks of the Society.

2. Professor M'Kendrick showed “Some Experiments illustrating the Action of the Drum of the Ear in the transmission of Musical Sounds,” for which he received the thanks of the Society.

3. The Secretary stated that he had received a letter from Dr. Irvine resigning the Membership of the Society, and that, therefore, the motion announced in Dr. Irvine's name could not be proceeded with.

4. With the permission of the Meeting, and on the suggestion of the President, Mr. John Mann withdrew the motion standing in his name.

5. Mr. John Turnbull, Jun., Engineer, 184 Buchanan Street, was recommended for the Membership of the Society by Mr. William [illegible], Mr. David Rowan, and Professor M'Kendrick.

The Society held another Meeting on 26th April, 1882, when the following papers were read:—(1) “On the relative Advantages of the different Methods which have been proposed for Determining the Solar Parallax,” by Professor Grant, LL.D.; (2) “On Dr. Siemens' Regenerating Gas Burners,” by Mr. William Foulis, C.E.; and (3) “On a new kind of Pump,” by Mr. W. P. Buchan. Reports were also given in from the various Sections. The Minutes of this Meeting, if approved, will appear in next volume of the *Proceedings*.

(Signed) WILLIAM WALLACE.

Report of the Architectural Section of the Glasgow Philosophical Society, for Session 1881-82.

During the Session six Meetings have been held. The following is the list of papers read at those Meetings:—

January 30, 1882.—Opening Address by the President, James Sellars, Jun., Esq., Architect.

February 13, 1882.—T. L. Watson, Esq., Architect, read a paper entitled "Notes upon Natural Laws of Proportion."

February 27, 1882.—Alexander Frew, Esq., C.E., read a paper —subject, "Highways and Byeways."

March 13, 1882.—David Thomson, Esq., Architect, F.R.I.B.A., read a paper—subject, "The Works of the late Charles Wilson, Esq., Architect."

March 27, 1882.—An interesting discussion took place on the comparative merits of the different methods of taking out quantities and receiving offers.

April 10, 1882.—John T. T. Brown, Esq., Writer, read a paper —subject, "The Law relating to Building Contracts."

The thanks of the Section are due to all these gentlemen.

During the Session only three new Associates were admitted.

The Annual Business Meeting was held on the evening of March 27, and the following gentlemen were elected to office :—

President.—James Sellars, Esq., Architect.

Vice-Presidents.—William Landless, Esq., Architect, and John Dansken, Esq., Measurer.

Treasurer.—James Howell, Esq., Measurer.

Hon. Secretary.—A. Lindsay Miller, Architect, 121 West Regent Street.

Members of Council.—John Honeyman, Esq., Architect; David Thomson, Esq., Architect; Robert Turnbull, Esq., Architect; Campbell Douglas, Esq., Architect; T. L. Watson, Esq., Architect; Alexander Muir, Esq., Builder; John Cowan, Esq., Wright; Alexander Frew, Esq., C.E.; William Howell, Esq., Measurer; Robert Scott, Esq., Measurer.

Your obedient Servant,

(Signed) A. LINDSAY MILLER,

Hon. Secretary.

REPORT OF THE BIOLOGICAL SECTION FOR SESSION 1881-82.

The Office-bearers* are the same as for last Session. During the year papers were passed on to be read before the Philosophical Society from Mr. James Thomson, F.G.S., Dr. J. C. M'Vail, M.D., Kilmarnock, and J. [illegible] [illegible], M.B.

(Signed) J. C. M'VAIL, M.B.,
Secretary of Section.

REPORT OF THE CHEMICAL SECTION FOR SESSION 1881-82.

During Session 1881-82 this Section held eleven General Meetings, at which the average attendance was 35. Seven gentlemen were admitted Associates of the Section in the course of the Session.

The following is a list of papers contributed to the Section:—

November 7, 1881.—"The President's Opening Address—"The History of the Technology of Oil of Vitriol.""

November 21, 1881.—"Recent Advances in the Production of Soda by Chemical Means," by Mr. [illegible].

December 5, 1881.—Dr. Wallace re-delivered his Opening Address to the Philosophical Society, "On the Dissociation of Chemical Compounds."

December 19, 1881.—"On Dephosphorisation of Iron and Steel," by Mr. J. Snodgrass.

January 9, 1882.—1. "On Fossilisation of Wood," by Mr. [illegible]. 2. "On the Valuation of Crude Saltpetre," by Mr. Tatlock. 3. "On Fireproofing of Cotton and other Fabrics," by Mr. Tatlock.

January 23, 1882.—* "On the Occurrence of Opals in Central Australia," by Dr. James B. M. [illegible].

February 6, 1882.—"On Japanese Bronze and Cloisonné Works," by Mr. Jokichi Takamine.

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* List of Office-bearers will be found on p. 625.

February 20, 1882.—"On Precipitation," by Dr. Mills.

March 6, 1882.—"On the Chemical Works of Nicholas Le Febvre," by Professor Ferguson.

March 20, 1882.—(1) * "On the Composition of some Fossil Eggs from the Peruvian Guano Deposits," by Dr. John Clark. (2) * "On the Action of Ammonia on Fats at a High Temperature," by Mr. T. N. Whitelaw.

April 3, 1882.—"The History of Explosives," by Mr. Tatlock.

The papers—four in number—marked with an asterisk, were recommended to the Council of the Philosophical Society for publication.

A full report of the discussions, taken by Mr. Cunningham, Shorthand Reporter to the Section, is preserved amongst the papers of the Section.

(Signed) ARTHUR WINGATE,
Secretary of Section.

REPORT OF THE SANITARY AND SOCIAL ECONOMY SECTION FOR SESSION 1881-82.

The Office-bearers of this Section were elected at a Meeting held for the purpose in the Society's Rooms, on the evening of November 16, 1881. The following gentlemen were elected:—

MR. EDWARD C. C. STANFORD, F.C.S., *President.*
JAMES CHRISTIE, M.D., } *Vice-Presidents.*
MR. KENNETH M. MACLEOD, }
EBEN. DUNCAN, M.D., 4 Royal Crescent, Crosshill, *Secretary.*

Other Members of Council.

MR. W. R. W. SMITH.
R. RENFREW, M.D.
MR. A. FREW.
MR. ARCHIBALD HEWAT.
NEIL CARMICHAEL, M.D.
MR. JOHN HONEYMAN.
MR. JOHN A. SPENS.
MR. P. W. DIXON.
MR. W. P. BUCHAN.
MR. ALEXANDER SCOTT.
MR. ALEXANDER WHITELAW.
JAMES B. RUSSELL, B.A., M.D.

At a Meeting of the Council of the Section, held on the 15th of January, the remit from the parent Society—"that the Sanitary Section should take measures towards the amendment of the Health of Scotland Act (1867)"—was considered. After discussion, it was agreed that a Committee should be appointed to consider in what directions the Act required amendment, and that the Committee should draw up a Report for the consideration of a Meeting of the Section, to be called for that purpose. The following Committee was appointed:—

Sherif Spens, Drs. Fergus, Russell, and Duncan; Messrs. Stanford, Honeyman, and Cleland Burns—Dr. Duncan, Convener.

This Committee has held several Meetings, and has the matter still under consideration. The Committee hope to have a Report ready for an early Meeting of the Section.

Of the papers from this Section recommended to be read before the Society, the paper by Dr. Russell, entitled "The Decade of 1871-80 in Glasgow—a Sanitary Retrospect," was read on 30th November. An address by the President of the Section, and a paper by Mr. Kenneth Macleod, have been deferred till next Session.

(Signed) Eben. Duncan.

Secretary to the Sanitary and Social Economy Section.

OFFICE-BEARERS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW.

SESSION 1881-82.

WILLIAM WALLACE, PH.D., F.R.S.E., F.I.C., F.C.S., *President.*

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PROFESSOR ROBERT GRANT, M.A., LL.D., F.R.S.,
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MR. ROBERT R. TATLOCK, F.R.S.E., F.I.C., F.C.S., *Chemical Section,*
MR. EDWARD C. C. STANFORD, F.C.S., *Sanitary and Social Economy Section,*
Presidents of Sections.

Other Members of Council.

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Dr. [illegible] [illegible].
Dr. Ebenezer Watson.
Mr. William [illegible].
Mr. [illegible] [illegible].
Mr. Richard [illegible].
Mr. John Jex Long.
Dr. W. [illegible] [illegible].
Mr. James Sellars, Jun.
Mr. [illegible] [illegible].

Professor [illegible] [illegible], Convener.

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Professor [illegible].
Dr. [illegible].
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Mr. Russell.	Mr. Nathaniel Dunlop.
Mr. Hamilton R. Robson.	Mr. John Jex Long.

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Mr. Campbell Douglas, I.A.
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Mr. D. Thomson, I.A., F.R.I.B.A.
Mr. Robert Turnbull, I.A.
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Mr. Alexander Muir.
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Mr. T. L. Watson.

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* For list of Office-bearers for [illegible], see p. [illegible].

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Professor Ferguson, M.A.,
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Mr. Alexander Whitelaw,
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Mr. J. E. Stoddart.
Mr. C. Hope.
Prof. Dittmar, F.R.S.E.
Mr. J. Snodgrass, F.C.S.
Mr. J. B. Hannay, F.R.S.E.
Mr. J. Mayer, F.C.S., &c.

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Mr. Kenneth M. Macleod,
} *Vice-Presidents.*

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Mr. Alexander Scott.
Mr. Alexander Whitelaw.
James B. Russell, B.A., .D.

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DONATIONS.	PRESENTED BY
Farriery: including the Medical and Surgical Treatment of Animals. Part 2,	The Commissioners of Patents.
Electricity and Magnetism. Div. IV., Parts 1-2,	,,
Dressing and Finishing Woven Fabrics, etc. Part 2,	,,
Palæontologia Indica. Vol. III., 2,	Geological Survey Office, Calcutta.
,, ,, Supplement III., 1,	
,, ,, Index. Vols. I., II.,	,,
Memoirs of the Geological Survey of India. Vol. XVI., 2-3,	,,
Records of the Geological Survey of India. Vols. XIII., 3-4, and XIV.,	,,
Memoires de l'Academie Royale des Sciences de Suède. Vols. XIV., 2, to XVII.,	The Academy.
Supplément aux Memoires. Vols. IV., V.,	,,
Bulletin. Nos. 34 to 37,	,,
The Scientific Roll. Vol. I., No. 4,	Mr. Alex. Ramsay.
Proceedings of the Institution of Civil Engineers. Vol. LXV.,	The Institution.
Annual Report of the Leeds Philosophical and Literary Society, 1880-81,	The Society.
The Mayor's Message to the Municipal Assembly of the City of St. Louis, 1880,	The Mayor.
Electricity in Surgery; Faure's Storage Battery; also Swan's Electric Light. By Dr. George Buchanan. Pamphlet. 1881,	The Author.
Memorial of Joseph Henry, 1880,	Smithsonian Institution.
Archives Neerlandaises. Vol. XVI. 1-5.	La Societe Hollandaise.
Archives du Musée Teyler, 2nd Series, Part 1,	,,
Bulletin and Memoirs of the Imperial University of Kazan. Six Vols.,	The University.
Account of the Strata of Northumberland and Durham, as proved by borings and sinkings, 1881,	North of England Institute of Mining Engineers.
First Annual Report of the United States Geological Survey, 1880,	Mr. King, Director.
Bulletin of the United States Geological and Geographical Survey of the Territories. Vol. VI., 2, 1881,	F. V. Hayden.
Transactions of the Royal Society of Victoria. Vol. XVII. 1881,	The Society.
Memorias da Academia Real das Sciencias de Lisboa,	The Academy.
1st Class, Vols. V., 2, VI., 1,	,,
2nd Class, Vol. V., 1,	,,
Jornal de Sciencias Mathematicas, &c. No. 24 to 29,	,,
Historia dos Estabelecementos Scientificos. Vols. VIII., IX.,	,,
Relatorio da Sessão, 1880,	,,

DONATIONS.	PRESENTED BY
Ueber die Zersetzung der Substitutionsproducte der niederen Fettsäuren. By George C. Thomson,	The Author.
Practical Ventilation and Warming. By Joseph Constantine,	The Author.
Washington Astronomical and Meteorological Observations for 1876. Two Vols.,	U. S. Naval Observatory.
Washington Astronomical Total Eclipses of the Sun of July 29th, 1878, and Jany. 11th, 1880,	,,
Atti della R. Academia dei Lincei. Nine Vols. and Four Parts,	Sir Wm. Thomson.
Transactions of the Institution of Engineers and Shipbuilders in Scotland. Vol. XXIV.,	The Institution.
Das Gehörorgan der Wirbelthiere. Von Gustav Retzius. Vol. I. Das Gehörorgan der Amphibien und Fische,	The Author.
Clinical Manual for the Study of Medical Cases. By Dr. James Finlayson. 1878,	,,
The Normal Temperature of Children. By Dr. Finlayson,	,,
On the Hours of Maximum Mortality in Acute and Chronic Diseases. By Dr. Finlayson,	,,
Case of Paroxysmal Hæmatinuria. By Dr. R. W. Forrest,	,,
Two Cases of Paroxysmal Hæmatinuria: with Note on the Spectroscopic Examination. By Dr. Forrest and Dr. Finlayson,	,,
Proceedings of the Literary and Philosophical Society of Liverpool. 1877-8,	The Society.
Die Naturgesetze. 2nd Supplement, 2nd Theile. By Dr. Hermann Scheffler,	The Author.
The Decennial Census. By J. B. R. 1881,	,,
Sculptured Tope on an old Stone at Dras, Ladak. By William Simpson. 1882,	,,
Annuaire de l'Observatoire de Montsouris. Météorologie, 1882,	The Observatory.
The Towers and Steeples designed by Sir Christopher Wren,	Mr. John Brown.
Calendar of the Pharmaceutical Society of Great Britain, 1882,	The Society.
Journal de l'École Polytechnique. Tomes XXX., XXXI.,	L'École.
Memoirs of the Astronomical Society. Vol. XLIV.,	The Society.
Calendar of the Department of Law, Science, and Literature of the University of Tokio, Japan. 1880-1,	The University.
Memoirs of the Scientific Department,	,,

DONATIONS.	PRESENTED BY
Verhandelingen der Koninklijke Akademie van Wetenschappen Natuurkunde. Dl. 21,	The Academy.
Verslagen en Mededeelingen, Afd. Natuurkunde. Dl. 16,	,,
Verslagen en Mededeelingen, Afd. Letterkunde. Dl. 10,	,,
Jaarboek, 1880,	,,
Proces Verbaal, 1880-1,	,,
Tria Carmina Latina,	,,
A Treatise on the Theory of Determinants. By Thomas Muir, M.A.,	The Author.
Scientific Proceedings of the Ohio Mechanics' Institute. Vol. I. 1,	The Institute.
Proceedings of the Physico-Chemical Society of the University of St. Petersburg. 1881,	The Society.
Proceedings of the Belfast Natural History and Philosophical Society. 1880-1,	The Society.
Transactions of the Glasgow Society of Field Naturalists. Five Parts,	The Society.
Transactions of the Insurance and Actuarial Society of Glasgow. Parts 1-3,	The Society.
Proceedings of the Institution of Civil Engineers Vol. LXVII.,	The Institution.
The Spelling Reformer, 1880–1,	Dr. Muirhead.
Obituary Notice of Sir Robert Christison and Sir C. Wyville Thomson. By John H. Balfour. 1882,	The Author.
Report on the Kelvingrove Museum and the Corporation Galleries of Art, 1881. By James Paton,	The Author.
Air-Refrigerating Machinery and its Applications. 1882. By J. J. Coleman,	The Author.
Annals of the New York Academy of Sciences. Vols. I., 14, and II., 1-6,	The Academy.
United States Geographical Surveys West of the 100th Meridian. Vol. VII.—Archæology,	Mr. G. M. Wheeler.
The Gas Question: Economic and Sanitary. By Dr. Adams,	The Author.
History of St. Andrew's Church for the last Hundred Years. By David Runciman. 1860.	
Report of the Mitchell Library, 1881,	The Library Committee.

NOTE.—The *Transactions* of all the Societies mentioned on pp. 631-2-3, are received in exchange for the *Proceedings* of this Society.

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The Statesman's Year Book. By F. Martin. 1882.
Transactions of the Royal Society of London. Vol. CLXXIII., Part 3.
Geological Sketches at Home and Abroad. By Archibald Geikie. 1882.
Ants, Bees, and Wasps. By Sir John Lubbock. 1882.
Geological Maps of Scotland.

The Philosophical Society Exchanges with the following Societies, &c.—

Academia Real das Sciencias de Lisboa,	Lisbon.
Academy of Natural Sciences of Philadelphia,	Philadelphia.
Academy of Science,	Connecticut.
Academy of Science,	St. Louis.
American Academy of Arts and Sciences,	Boston.
American Pharmaceutical Society,	Philadelphia.
American Philosophical Society,	Philadelphia.
Anthropological Institute,	London.
Astor Library, New York,	New York.
Library of Royal Observatory,	Melbourne.
Bath Natural History and Antiquarian Field Club,	Bath.
Belfast Natural History and Philosophical Society,	Belfast.
Berwickshire Naturalists' Club,	Alnwick.
Biblical Archæology,	London.
Birkenhead Literary and Scientific Society,	Birkenhead.
Birmingham Philosophical Society,	Birmingham.
Boston Natural History Society,	Boston.
Boston Public Library,	,,
Botanical Society of Edinburgh,	Edinburgh.
Bristol Naturalists' Society,	Bristol.
Buffalo Society of Natural Sciences,	Buffalo.
Bureau Scientifique, Central Neerlandais,	Harlem.
California Academy of Sciences,	California.
Cambridge Philosophical Society,	Cambridge.
Canadian Institute,	Canada.
Chemical Society,	London.
Cleveland Institution of Engineers,	Middlesborough.
Commissioners of Patents,	London.
Davenport Academy of Natural Sciences,	Davenport, Iowa.
Die Deutsche Chemische Gesellschaft,	Berlin.
Dublin University Biological Association,	Dublin.
École Polytechnique,	Paris.
Edinburgh Geological Society,	Edinburgh.
Entomological Society of Ontario,	London, Ontario.
Epping Forest and County of Essex Naturalists' Field Club,	Buckhurst Hill, Essex.
Franklin Institute,	Philadelphia.

Geographical Society.	Geneva.
Geological Society of Glasgow.	Glasgow.
Geological Survey of Canada.	Montreal.
Geological Survey of India.	Calcutta.
Glasgow Archaeological Society.	Glasgow.
Hertfordshire Natural History Society and Field Club.	Watford, Herts.
Historic Society of Lancashire and Cheshire.	Liverpool.
Institution of Civil Engineers.	London.
Institution of Engineers and Shipbuilders in Scotland.	Glasgow.
Institution of Mechanical Engineers.	Birmingham.
Institution of Mechanical Engineers.	London.
Insurance and Actuarial Society of Glasgow.	Glasgow.
Kasan Imperial University.	Kasan.
K. A. Akademie van Wetenschappen.	Amsterdam.
Leicester Literary and Philosophical Society.	Leicester.
Literary and Historical Society of Quebec.	Quebec.
Literary and Philosophical Society of Leeds.	Leeds.
Literary and Philosophical Society of Liverpool.	Liverpool.
Literary and Philosophical Society of Manchester.	Manchester.
Liverpool Geological Society.	Liverpool.
Liverpool Polytechnic Society.	Liverpool.
London Geological Society.	London.
Manchester Scientific Students' Association.	Manchester.
Meteorological Observatory.	Montsouris, Paris.
Middlesex Hospital.	London.
Midland Institute of Mining Engineers.	Barnsley.
Mining Institute of Scotland.	Hamilton.
Musée Teyler.	Harlem.
National Academy.	Washington.
National Observatory.	—
Natural History Society.	Glasgow.
Naturalists' Union.	Huddersfield.
Newcastle-upon-Tyne Chemical Society.	Newcastle-on-Tyne.
New York Academy of Sciences.	New York.
New Zealand Institute.	Wellington.
North of England Institute of Mining Engineers.	Newcastle-on-Tyne.
N. Staffordshire Institute of Mining and Mechanical Engineers.	London.
Observatoire Royal de Bruxelles.	Bruxelles.
Ophthalmological Society.	London.
Ohio Mechanics' Institute.	Cincinnati.
Pharmaceutical Society.	London.
Photographic Society.	„
Philadelphia Alumni Association.	Philadelphia.
Physical Society of London.	London.
Physico-Chemical Society, University of St. Petersburg.	St. Petersburg.
Powys-land Club.	Liverpool.
Publisher of Engineering.	London.

Registrar-General,	Melbourne.
Royal Academy of Science,	Berlin.
Royal Academy of Science,	Brussels.
Royal Academy of Science,	Stockholm.
Royal Astronomical Society,	London.
Royal Cornwall Polytechnic Society,	Falmouth.
Royal Dublin Society,	Dublin.
Royal Geographical Society,	London.
Royal Geographical Society,	Vienna.
Royal Institute of British Architects,	London.
Royal Institute of Lombardy,	Milan.
Royal Institution of Cornwall,	Truro.
Royal Institution of Great Britain,	London.
Royal Irish Academy,	Dublin.
Royal Microscopical Society,	London.
Royal Physical Society of Edinburgh,	Edinburgh.
Royal Scottish Society of Arts,	,,
Royal Society of Edinburgh,	,,
Royal Society of London,	London.
Royal Society of Victoria,	Melbourne.
School of Mines,	New York.
Scottish Meteorological Society,	Edinburgh.
Smithsonian Institution,	Washington.
Social Science Association,	London.
Société des Sciences Physiques et Naturelles,	Bordeaux.
Société Royal des Sciences de Liége,	Liége,
Society of Arts,	London.
Society of Engineers,	,,
South Wales Institute of Engineers,	Swansea.
Statistical Society,	London.
United States Geologist,	Washington.
United States Observatory,	,,
United States Survey,	,,
University of Christiania,	Christiania.
University of Tokio, Japan,	Tokio, Japan.
Verein für Erdkunde zu Halle,	Halle.
Videnskabs-Selskabet i Christiania,	Christiania.
Washburn Observatory—University of Wisconsin,	Washburn.

LIST OF PERIODICALS.

WEEKLY.

Academy.
Architect.
Athenaeum.
British Architect.
British Medical Journal.
Builder.
Building News.
Chemical News.
Comptes Rendus.
Electrician.
Engineer.
Engineering.
English Mechanic.
Iron.
Journal of the Society of Arts.
Journal of Gas Lighting.
Nature.
Notes and Queries.
Pharmaceutical Journal.
Scientific American.

FORTNIGHTLY.

Berichte der Deutschen Chemischen Gesellschaft.
Bulletin de la Société Chimique de Paris.
Journal für Praktische Chemie.
Polytechnisches Journal.
Telegraphic Journal.

MONTHLY.

American Journal of Science and Arts.
Annales de Chimie et de Physique.
Annales des Ponts et des Chaussées.
Annales des Sciences Naturelles—Botanique.
Annales des Sciences Naturelles—Zoologie.
Annalen der Chemie.
Annalen der Physik und Chemie.
Annals and Magazine of Natural History.
Analyst.
Antiquary.
Beiblätter zu den Annalen der Physik und Chemie.
Bulletin de la Société d'Encouragement.
Bulletin de la Société Géologique de France.
Bulletin Mensuel de l'Observatoire de Montsouris.
Canadian Entomologist.
Chemische Industrie.
Entomologist.
Entomologists' Monthly Magazine.
Journal of the Franklin Institute.
Geological Magazine.
Hardwicke's Science Gossip.
Journal de Pharmacie et de Chimie.
Journal of Botany.
Monthly Notes of the Library Association.
Journal of the Photographic Society.
Journal of Science.
Journal of the Chemical Society.
London, Edinburgh, and Dublin Philosophical Magazine.
Midland Naturalist.
Monatsbericht der Königlich Preussischen Akademie der Wissenschaften zu Berlin.
Naturalist.
Odontological Society's Transactions.
Proceedings of Royal Society of London.
Proceedings of Royal Geographical Society.
Royal Astronomical Society's Monthly Notices.
Sanitary Journal.
Zoologist.

QUARTERLY.

- Annales des Mines.
- Bulletin de la Société Industrielle de Mulhouse.
- Grevillea.
- Journal of Anatomy and Physiology.
- Journal of the Royal Agricultural Society of England.
- Journal of the Scottish Meteorological Society.
- Journal of the Statistical Society.
- Mind: a Quarterly Review of Psychology and Philosophy.
- Quarterly Journal of Geological Society.
- Quarterly Journal of Microscopical Science.
- Quarterly Journal of Ornithology.
- Quarterly Journal of Pure and Applied Mathematics.
- Revue Universelle des Mines.
- Scottish Naturalist.
- Zeitschrift für Analytische Chemie.

LIST OF MEMBERS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW,

FOR 1881-82.

* *Denotes Life Members.*

HONORARY MEMBERS.

(Limited to Twenty.)

WITH YEAR OF ELECTION.

FOREIGN.

Michael Eugene Chevreul, Paris,	1860
Jean Babtiste Dumas, Paris,	1860
Hermann Helmholtz, Berlin,	1860
Albert Kölliker, Wurtzburg,	1860
5 Wilhelm Weber, Göttingen,	1860
Ernst Haeckel, Jena,	1880

AMERICAN AND COLONIAL.

James D. Dana, LL.D., Professor in Yale College, Connecticut,	1860
Professor Loomis, New York,	1860
Robert Lewis John Ellery, F.R.A.S., Victoria,	1874

BRITISH.

10 John Hutton Balfour, A.M., M.D., LL.D., F.R.SS. L. & E., Edinburgh,	1850
James Prescott Joule, LL.D., F.R.S., Manchester,	1860
Sir Edward Sabine, General, K.C.B., R.A., LL.D., D.C.L., F.R.S., &c.,	1860
Sir A. C. Ramsay, LL.D., F.R.S., London,	1874
Sir Joseph Dalton Hooker, K.C.B., K.C.S.I., M.D., D.C.L., LL.D., Kew, London,	1874
15 Robert Angus Smith, LL.D., F.R.S., &c., Manchester,	1874
Thomas Henry Huxley, Ph.D., LL.D., F.R.S., &c., London,	1876
Allen Thomson, M.D., D.C.L., LL.D., F.R.S., &c., London,	1878
Herbert Spencer, London,	1879
John Tyndall, LL.D., D.C.L., F.R.S., &c., London,	1880
20 Andrew Buchanan,* M.D., LL.D., Glasgow,	1880

CORRESPONDING MEMBERS.

WITH YEAR OF ELECTION.

Rev. H. W. Crosskey, LL.D., F.G.S., 28 George road, Birmingham,	1874
Robert Gray, F.R.S.S., Bank of Scotland, Edinburgh,	1874
A. S. Herschel, R.A., F.R.A.S., Professor in College of Science, 16 Saville row, Newcastle-on-Tyne,	1874
Thomas E. Thorpe, Ph.D., F.R.S., &c., Professor of Chemistry in Yorkshire Leeds, College,	1874

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* Died 9th July, 1882.

ORDINARY MEMBERS.

WITH YEAR OF ENTRY.

Adams, James, 9 Royal crescent. 1874
Adam, William, M.A., 36 Annette street, Govanhill. 1876
Addie, John, 144 St. Vincent street. 1861
Alexander, Jas. W., 3 Fitzroy place. 1876
5 Alexander, Thos., 8 Sardinia terrace. 1869
Anderson, Alexander, 114 Trongate. 1869
Anderson, David H., Atlantic Mills, Bridgeton. 1875
Anderson, Geo., M.P., Western Club. 1856
Anderson, John, Bank of Scotland, Barrhead. 1873
10 Anderson, J. T., 41 Westbourne gardens. 1881
*Anderson, T. M'Call, M.D., Professor of Clinical Medicine in the University of Glasgow, 14 Woodside crescent. 1873
Anderson, W. F. G., 47 Union street. 1878
Armstrong, Wm. J., 3 Royal Exchange court. 1871
Arnot, James Craig, 162 St. Vincent st. 1869
15 Arrol, Archibald, 16 Dixon street. 1869
Arrol, Walter, 16 Dixon street. 1869
Arrol, William A., 16 Dixon street. 1869
Arthur, Wm. Rae, 1 Crown gardens, Dowanhill. 1850

Bain, Sir James, F.R.S.E., 3 Park terrace. 1866
20 Bain, Robert, 22 Dundas street. 1869
Baird, Alex. Smith, 26 Sardinia terrace, Hillhead. 1870
Baldie, Robert, I.A., 83 Bath street. 1870
Ball, Henry W., Cranstonhill Engine Works. 1875
Balloch, Robert, 133 St. Vincent st. 1843
25 Balmain, Thos., 1 Kew terrace, Kelvinside. 1881
Barclay, Charles H., 28 Westbourne gardens. 1881
Barclay, James, 36 Windsor terrace. 1872
Barclay, John, 37 Monteith row. 1881
Barlow, John, M.D., Professor of Physiology in Anderson's College. 1880
30 Barrett, Francis Thornton, Mitchell Library. 1880
Barr, Thos., M.D., F.F.P. & S.G., 10 Albany place. 1879
Bayne, A. Malloch, 1 Hamilton terrace, Partick, 1878
Beatson, George T., M.D., 2 Royal crescent. 1881
*Beith, Gilbert, 19 West Nile street. 1881
35 Bell, Dugald, 27 Lansdowne cres. 1871
Bell, George, F.R.I.B.A., 212 St. Vincent street. 1870
*Bell, Henry, 446 Camden road, London, N. 1876
Bell, James, 116 Mains street. 1843
Bell, James, 172 Argyle street. 1877
40 Bell, Robt., M.D., F.F.P.S.G. and Ed., 29 Lynedoch street. 1869
Binnie, J., 69 Bath street. 1877
Binnie, Robert, Ashbourne, Gourock. 1881
Black, Adam Elliot, C.A., F.C.S., Leabank, Crosshill. 1880
Black, D. A., 214 Bath street. 1880
45 Black, D. Campbell, M.D., M.R.C.S.E., 50 Woodlands road. 1872
Black, J. Albert. 33 Lynedoch st. 1869
Black, John, 16 Park terrace. 1869
Black, Malcolm, M.B., C.M., 5 Canning place. 1880
*Blackie, J. Alexander, 17 Stanhope street. 1881
50 *Blackie, J. Robertson, 17 Stanhope street. 1881
Blackie, Robert, 17 Stanhope street. 1847
Blackie, W. G., Ph.D., F.R.G.S., 17 Stanhope street. 1841
Blair, Charles J., 6 Alfred terrace, Hillhead. 1881
Blair, G. M'Lellan, 2 Lilybank ter. 1869
55 Blair, J. M'Lellan, 8 Cecil pl., Paisley road. 1869
Blyth, James, M.A., F.R.S.E., Professor of Natural Philosophy in Anderson's College. 1881
Bost, Timothy, 33 Renfield street. 1876
Bottomley, James T., M.A., F.R.S.E., F.C.S., Demonstrator in Natural Philosophy, University of Glasgow, 2 Eton terrace, Hillhead. 1880
Bottomley, Wm., Junr., C.E., University. 1880
60 Boucher, J., I.A., 247 St. Vincent street. 1870
Bowie, Campbell T., 26 Bothwell street. 1870
Boyd, John, Shettleston Iron Works, near Glasgow. 1873
Boyd, Wm., Blythswood Foundry, 61 North street. 1852
Brand, James, C.E., 123 Hope street. 1880
65 Brock, W. J., M.B., C.M., 2 Holyrood crescent. 1881
Brodie, John Ewan, M.D., C.M., F.F.P.S.G., 20 Sandyford place. 1873
Bromhead, Horatio K., I.A., A.R.I.B.A., 245 St. Vincent st. 1870
Brown, James, 76 St. Vincent street. 1876
Brown, James F., 28 Hamilton park terrace, Hillhead. 1877

[illegible]

[illegible] I.A., 1[illegible]3 West [illegible] st. 187[illegible]

[illegible] David, 120 Buchanan street. 187[illegible]

[illegible] F.R.I.B.A., 15 [illegible] street. 187[illegible]

Buchanan, W[illegible] 21 Renfrew street. 1875

Buchanan, [illegible] M.D., Professor [illegible] St. George's r[illegible] 1870

Buchanan, [illegible] street. 1881

Buchanan, [illegible] M.D., Professor [illegible] Surgery in the University of Glasgow, 1[illegible]3 Bath street. 1875

Buchanan, Geo. S., [illegible] 1845

Buchanan, William [illegible] St. Vincent street. 1873

Buchanan, William, 1[illegible] Carrington street, West. 1881

Burnet, John, I.A., 10[illegible] St. Vincent street. 1850

Burnet, Lindsay, Assoc. M.I.C.E., St. Kilda, Dowanhill. 1882

Burns, J., M.D., 15 Fitzroy place, Sauchiehall street. 1864

Burns, J. Cleland, Ferntower, Crieff. 1874

Cameron, Charles, M.D., LL.D., M.P., 1[illegible]4 Union street. 1870

Cameron, H. C., M.D., 27 Elmbank crescent. 1873

Cameron, R., 123 St. Vincent st. 1873

[illegible] A., LL.D., M.P., 29 Ingram street. 1848

[illegible] John D., Merroughsdale [illegible], Copeland road, Govan. 1858

[illegible] Louis, 3 Eton terrace, Hillhead. 1881

[illegible] William, 24 Ingram st. 1880

[illegible] Thomas, 23 West Nile st. 1851

[illegible] Charles, 141 St. Vincent st. 1870

[illegible] Neil, M.D., C.M., 29 [illegible] street. 1873

Carmichael, Thomas, 9 Windsor st., New City road. 187[illegible]

Carrick, John, I.A., City Architect, 72 Hutcheson street. [illegible]

Cassels, Robert, 168 St. Vincent st. 185[illegible]

Cassels, J. P., M.D., 2 Newton ter. 187[illegible]

[illegible] James M., Clutha cottage, [illegible] 187[illegible]

[illegible] George G., 9 Rillbank terrace, Edinburgh. 1881

[illegible] James, A.M., M.D., F.F.P.S.G., 2 Great Kelvin terrace, Bank street, Hillhead. 187[illegible]

[illegible] Turkey-red Works, [illegible] Dumbartonshire. 18[illegible]

[illegible] J., Shawfield Works, [illegible] 188[illegible]

[illegible] James, 28 Renfield street. 18[illegible]

[illegible] 29 St. Vincent street. 1855

[illegible] 5 Sandyford pl. 187[illegible]

[illegible] A., [illegible]-creek house. 1877

[illegible] L.R.C.S. Eng., [illegible] street. 187[illegible]

12[illegible] [illegible] F.I.C., F.C.S., [illegible] street. 187[illegible]

[illegible] Wilton crescent. 187[illegible]

[illegible] 1876

[illegible] Gordon street. 18[illegible]

[illegible] Bridge [illegible] 1871

125 [illegible] 1 Holland place. 18[illegible]

[illegible] Park terrace. 18[illegible]

Coats, George, M.D., 7 Elmbank crescent. 1873

*Cochran, [illegible] 7 Crown circus, Dowanhill. 1877

Coghill, Wm. C., 2[illegible]3 Argyle street 1873

130 Coleman, J. J., F.C.S., 45 West Nile street. 1860

Collins, Sir Wm., 3 [illegible] ter., East. 1860

Collins, Wm., Jun., 130 Stirling rd. 1870

Colquhoun, Jas., 158 St. Vincent street. 187[illegible]

Combe, George James, 34 Dundas st. 1877

135 Combe, William, Regent terrace, Stirling road. 1877

Connal, Michael, Virginia buildings. *Vice-President.* 18[illegible]

Connell, James, 182 Crookston st. 187[illegible]

Connell, Wm., 38 St. Enoch square. 187[illegible]

Copeland, Jas., 1 Thornville terrace, Hillhead. 18[illegible]

140 Copland, Wm. R., M. Inst. C.E., 146 West Regent street. 18[illegible]

Coubrough, A. Sykes, Blanefield, Strathblane. 18[illegible]

Couper, James, Craigforth House, Stirling. 18[illegible]

Couper, James, 37 Lansdowne cres. 187[illegible]

Couper, Wm., 9 Huntly gardens, Hillhead. 1873

145 Cowan, John, 12 Ure place. 1870
Cowan, M'Taggart, C.E., 27 Ashton terrace, Hillhead. 1876
Cranston, George, Jun., 425 Sauchiehall street. 1880
Crawford, David, Jun., 5 Beechwood place, Dalmarnock road. 1873
Crawford, J. Law, 212 St. Vincent street. 1882
150 Crawford, W. B., 104 West Regent street. 1872
Cree, Thomas S., 17 Exchange sq. 1869
Cross, David, 25 Park circus. 1850
Cumming, J. Simpson, M.D., 310 St. Vincent street. 1874
Cunningham, John M., Clydesdale bank. 1881
155 Cunningham, J. R., Jun., 4 Derby crescent, Kelvinside. 1881
*Cuthbertson, John N., 29 Bath st. 1850

Dansken, A. B., 179 West George street. 1877
*Dansken, John, 121 W. Regent st. 1876
Darling, Geo. E., 178 St. Vincent street. 1870
160 Davidson, T., Jun., 33 Garngadhill. 1872
Davis, Henry, 16 Blythswood square. 1881
Day, St. John Vincent, C.E., F.R.S.E., 115 St. Vincent street. 1866
Deas, Jas., C.E., 7 Crown gardens, Dowanhill. 1869
Dempster, John, 33 Abbotsford place. 1875
165 Dennison, Wm., C.E., 175 Hope street. 1876
Dewar, Duncan, Kirkhill, Cambuslang. 1877
Dickie, James, 7 Claremont terrace. 1879
Dickson, James, 15 Binnie place. 1871
Dittmar, W., F.R.S.E., Professor of Chemistry, Anderson's College. 1875
170 Dixon, A. Dow, 10 Montgomerie crescent, Hillhead. 1873
Dixon, Edward M., B.Sc., 11 Hopetoun place. 1860
Dixon, Joseph Anthony, 121 St. Vincent street. 1870
Dixon, Peter W., 19 Elmbank cres. 1871
Dobbie, James Johnston, M.A., D.Sc., Assistant to the Professor of Chemistry, University, 292 St. Vincent street. 1880
175 Dodds, Rev. Jas., D.D., 15 Sandyford place. 1876
Donald, John, Thomson street Public School. 1872
Donald, William J. A., 29 St. Vincent place. 1877
Donald, Alex. W., Bank place, Cambuslang. 1880
Dougall, Franc Gibb, 167 Canning st. 1875
180 Dougall, John, M.D., F.F.P.S., Lecturer on Materia Medica in the Glasgow Royal Infirmary School of Medicine, 6 Belmar terrace, Shields road, Pollokshields. 1876
Douglas, Campbell, I.A., 266 St. Vincent street. 1870
Douie, Robert, 37 Bath street. 1869
Downie, James, North Bank house, Kirkintilloch. 1872
Downie, Robert, Jun., Carntyne Dye-works, Parkhead. 1872
185 Drew, Alex., 149 West George st. 1869
Dryburgh, Jas. N., Minerva cottage, Holmhead, Cathcart. 1872
Duff, M. Campbell, 145 St. Vincent street. 1880
Duncan, Alex., B.A., 242 St. Vincent street. 1878
Duncan, Eben., M.D., C.M., F.F.P.S.G., 4 Royal crescent, Crosshill. 1873
190 Duncan, Robert, Engineer, Partick Foundry. 1875
*Duncan, Walter, 9 Montgomerie cres. 1881
*Dunlop, Nathaniel, 1 Montgomerie crescent, Great Western road. 1870
Dunn, John S., Rockvilla Saw Mills, Port-Dundas. 1876
Dunn, Robert Hunter, 4 Belmont crescent. 1878

195 Easton, Robert, C.A., 115 Buchanan street. 1880
Easton, Walter, 32 Exchange sq. 1878
Easton, William J., 150 West Regent street. 1876
Edward, David, 92 Buchanan st. 1878
Elder, James, C.E., 204 St. Vincent street. 1881
200 Evans, Mortimer, C.E., F.G.S., 97 West Regent street. 1859

Fairlie, Colin B., C.E., 67 Renfield street. 1874
Fairweather, Wallace, C.E., 96 Buchanan street. 1880
Falconer, Patrick, 33 Hayburn crescent, Partick. 1876
Falconer, Thos., 50 Kelvingrove st. 1880
205 Farquhar, John, 13 Belhaven terrace. 1872
Fawsitt, Charles A., 4 Maule terrace, Partick. 1879
Fergus, And., M.D., M.R.C.S.Eng., 3 Elmbank cres. 1868
Fergus, Jas., 5 Burnbank gardens. 1880
Ferguson, John, M.A., Professor of Chemistry, University of Glasgow. 1869
210 Ferguson, Peter, 4 Linwood ter., Glasgow st., Hillhead. 1866
Fergusson, Alex. A., 48 M'Alpine st. 1847
Fife, William, 52 Glassford street. 1880

Finlay, Joseph, 9 Montgomerie drive, Kelvinside. 1873
Finlay, John, Moss Park, Albert road, Pollokshields. 1850
215 Finlay, Robert Gilchrist, Jun., Holmfield, Dalmuir. 1881
Finlayson, Jas., M.D., 351 Bath st. 1873
Fisher, Donald, 183 St. Vincent st. 1869
*Fleming, James, 7 Fitzroy place. 1880
*Fleming, William James, M.B., 155 Bath street. 1876
220 Forbes, Alex., Undercliffe cottage, Wemyss Bay. 1879
Foulds, John, L.D.S., 173 Bath st. 1877
Foulis, William, C.E., 42 Virginia street. 1870
*Fowler, John, Kelvinbank terrace, Sandyford. 1880
Frame, Thomas, Royal Bank place. 1863
225 Frazer, Daniel, 113 Buchanan st. 1853
Frew, Alex., C.E., 175 Hope street. 1876
Frew, Robert, M.E., 75 Bath street. 1874
Fulton, David, Duke Street Engraving Works, 24 Ark lane. 1872

Gairdner, W. T., M.D., Professor of Practice of Medicine in the University of Glasgow, 225 St. Vincent street. 1863
230 Galbraith, Andrew, 123 Hope st. 1857
Galbraith, William, 3 Blythswood square. 1868
Gale, Jas. M., C.E., Water Office, 23 Miller street. 1856
Galloway, T. Lindsay, C.E., Plantation quay, West. 1881
Gardner, Daniel, 36 Jamaica street. 1869
235 Garroway, John, 58 Buchanan st. 1875
Garroway, Robt., M.D., Rosemount, Cumbernauld road. 1859
Geddes, Wm., Battlefield, Langside. 1846
Gemmell, Wm., 150 Hope street. 1876
Gillies, Wm., Battlefield, Langside. 1869
240 Gillies, W. D., 96 Miller street. 1872
Gilmour, J. B., 50 North Hanover street. 1865
Gilfillan, Wm., 129 St. Vincent street. 1881
Glaister, John, M.B., 16 Grafton square. 1879
Goodwin, Robert, 58 Renfield st. 1875
245 Gorman, William, 153 West Nile st. 1860
Gossman, Adam, 70 Robertson st. 1870
Gourlay, John, C.A., 24 George square. 1874
Gourlay, Robert, Kirklee avenue, Great Western road. 1869
Gow, Alexander, 117 Ladbrooke Grove Road, Notting hill, London, W. 1869
Gow, Robert, Cairndowan, Dowanhill gardens. 1860
Graham, David, Jun., 140 Douglas street. 1870
Grant, Robt., M.A., LL.D., F.R.S., Professor of Astronomy in the University of Glasgow, Observatory, *Hon. Vice-President.* 1860
Gray, James, M.D., 15 Newton terrace. 1863
Gray, James, 12 Kelvingrove street. 1876
255 Greenlees, Alex., M.D., 405 St. Vincent street. 1864
Grierson, James, 5 Belhaven cres., Kelvinside. 1880
Grieve, John, M.D., care of W. L. Buchanan, 212 St. Vincent st. 1856
Grieve, Robert, L.R.C.S., Ed., 52 Holmhead street. 1872

Hamilton, Geo., 149 St. Vincent st. 1871
260 Hamilton, J. Struthers, Adelphi Cotton Works. 1869
Hamilton, Patrick, 149 St. Vincent street. 1854
Hamilton, David C., 21 Carlton place. 1880
Hannay, Anthony, 23 Exchange square. 1856
Hannay, Jas. B., F.R.S.E., F.C.S., Annfield Chemical Works, Sword street. 1879
265 Hannay, Thos., 166 Buchanan st. 1864
Hannay, Maxwell, 104 West George street. 1881
Harley, James, 57 Hope street. 1882
*Harvie, John, Secretary, Clydesdale Bank, 30 St. Vincent place. 1880
Hay, John, 12 Terrace street. 1870
270*Henderson, John, Jun., 4 Crown terrace, Dowanhill. 1879
Henderson, Thos. Brown, M.D., 17 Elmbank crescent. 1880
Henderson, Thos., 47 Union street. 1855
Henderson, Wm., 13 Annfield terrace, Partickhill. 1853
Henderson, Wm., 15 Cadogan st. 1873
275*Henderson, A. P., 10 Crown terrace, Dowanhill. 1880
Henry, R. W., Foremount terrace, Partick. 1875
Hewat, Arch., F.F.A., F.S.S., 122 St. Vincent street. 1877
Heys, Zechariah J., South Arthurlie, Barrhead. 1870
Higginbotham, James S., Springfield court, Queen street. 1874
280 Higgins, Henry, Jun., 243 St. Vincent street. 1878
Hill, Andrew, 22 Arlington street. 1877
Hilliard, Joseph, 65 Renfield street. 1878
Hodge, William, 15 Hillsborough square, Hillhead. 1878
Hoey, David G., 124 St. Vincent st. 1869

85 Hogg, Robert, 15 Cadogan street. 1865
Holt, T. G., 25 Wellington street. 1875
Honeyman, John, F.R.I.B.A., 140 Bath street. 1870
Horne, R. R., C.E., 150 Hope st. 1876
Howatt, James, 146 Buchanan st. 1870
90 Howatt, William, 146 Buchanan street. 1870
Hunt, Edmund, 87 St. Vincent street. 1856
*Hunt, John, Milton of Campsie, 1881
Hunter, A. C., 197 St. Vincent st. 1880
Hunter, James, Newmains house, Motherwell. 1854
95 Hunter, James, 156 St. Vincent st. 1874
Hutton, W. R., 149 Hill street, Garnethill. 1868

Inglis, Anthony, 64 Warroch street. 1854
Inglis, John, 64 Warroch street. 1850

*Jack, William, LL.D., Professor of Mathematics in the University of Glasgow. 1881
00 Jacks, William, 7 Royal Bank place. 1875
Jackson, Thomas, Western Club. 1857
Jacoby, Gustav, Prospect Villa, Montgomery terrace, Mount Florida. 1871
Jamieson, And., C.E., Principal of College of Science and Arts. 1881
Jamieson, John L. K., 9 Crown ter., Dowanhill. 1868
05 Johnstone, Jas., Coatbridge street, Port-Dundas. 1866

Kennedy, Hugh, Redclyffe, Partick. 1876
Kennedy, Thos., 42 Ingram street. 1869
Kennedy, Walter Stewart, Allanbank, Crosshill. 1873
Kennedy, William, Braemar villa, Pollokshields. 1882
10 Ker, William, 1 Windsor terrace, West. 1874
Kerr, Charles James, Greenfaulds house, Cumbernauld. 1877
Kerr, James Hy., 13 Virginia st. 1872
Kerr, John G., M.A., Allister Cottage, Cambuslang. 1878
Key, William, Tradeston Gas-works. 1877
15 King, James, 57 Hamilton drive, Hillhead. 1848
King, James, of Levernholm, 115 Wellington street. 1855
Kirk, Alexander C., 19 Athole gardens, Dowanhill. 1869
Kirk, Robert, M.D., Newton cottage, Partick. 1877
Kirkpatrick, Andrew J., 10 Woodside place. 1869
20 Kirkwood, Anderson, LL.D., 7 Melville terrace, Stirling. 1869
Kirsop, John, 98 Argyle street. 1855
Knox, Adam, 47 Crownpoint road. 1881
Knox, John, 129 West George st. 1870

Laidlaw, David, Chaseley, Skelmorlie. 1879
325 Laing, Alex., LL.D., 108 Douglas street. 1846
Laird, Geo., 10 Ann st., Bridgeton. 1870
Laird, John, Marchmont, Port-Glasgow. 1876
Laird, John, Royal Exchange Sale Rooms. 1879
Lamb, Thomas, 220 Parliamentary road. 1870
330 Lang, William, Jun., Crosspark, Partick. 1865
Leggatt, Robert, 38 Sauchiehall st. 1869
Latta, James, 8 Miller street. 1869
Latta, John, 138 W. George street. 1880
Lawson, John, Cranstonhill. 1880
335 Leisler, Louis, 130 Hope street. 1869
Lindsay, Archd. M., M.A., 87 West Regent street. 1872
Lindsay, Wm. G., 157 St. Vincent street. 1871
Livingston, Robert, 263B Argyle st. 1879
*Long, John Jex, 8 Whitevale. 1862
340 Lothian, J. Alexander, M.D., L.R.C.S.E., 6 Newton terrace. 1872
Low, James, 176 St. Vincent st. 1878

M'Alley, Robert, Chemical Works, Falkirk. 1872
M'Andrew, John, 17 Park st., East. 1843
Macarthur, J. G., 7 West Prince's street. 1874
345 M'Call, J., F.R.C.V.S., Prof. of Veterinary Medicine and Surgery, Veterinary College, 85 Buccleuch street. 1866
M'Callum, George, Rossbank, Cambuslang. 1850
M'Clure, David, 62 Argyle street. 1880
M'Conville, John, M.D., 11 Elmbank crescent. 1870
M'Crae, John, 7 Radnor street. 1876
350 M'Creath, James, M.E., 95 Bath street. 1874
M'Culloch, William, 50 Westbourne gardens, West. 1872
M'Culloch, Hugh, 236 St. George's road. 1880
Macdonald, Arch. G., 8 Park circus. 1869
Macdonald, Thomas, 109 Bath st. 1869
355 M'Ewan, Wm., Jun., 17 St. Vincent lane. 1869
Macfarlane, Samuel, Meadowbank, Torrance of Campsie. 187
Macfarlane, Walter, Saracen Foundry, Possil Park. 1855
M'Farlane, Walter, Printworks, Thornliebank. 1869

M'Neill, J. S., Ardenclutha, Windsor circus. 1880
[illegible] M'Gilvray, R. A., 122 West Regent street. 1880
M'Gregor, Duncan, F.R.G.S., 45 Clyde place. 1867
M'Gregor, Jas. W., 4 Gt. Western terrace, Hillhead. 1880
M'Gregor, James, 7 East India avenue, London, E.C. 1872
M'Gregor, Alexander B., LL.D., 172 St. Vincent street. [illegible]
[illegible] *M'Ilwraith, James, 4 Westbourne terrace, Kelvinside. 1872
M'Intyre, Peter, 30 Ingram street. 1873
Mackay, John, Jun., 28 Jamaica street. 1880
*M'Kenzie, W. J., Oakfield terrace, Hillhead. 1872
*M'Kenzie, W. D., 43 Renfield st. 1873
[illegible] M'Kendrick, John G., M.D., LL.D., C.M., F.R.C.P.E., F.R.S.E., Professor of Institutes of Medicine in the University of Glasgow, 13 Westbourne gardens, [illegible]. 1877
Mackinlay, David, 6 Great Western terrace, Hillhead. [illegible]
M'Kissack, John, 234 W. George street. 1881
M'Laren, Robert, Canal street, Port-Eglinton. [illegible]
M'Laren, William Ed., 13 Exchange place. 1873
[illegible] Maclay, David T., 169 W. George st. 1872
Maclean, A. H., 124 Queen street. [illegible]
Maclehose, James, 18 Victoria cres., Dowanhill. [illegible]
M'Lellan, John Young, Cumbernauld road. 1882
M'Lellan, Lewis, 7 Belhaven ter. 1880
[illegible] M'Lellan, Walter, 129 Trongate. [illegible]
M'Leod, Kenneth M., 1 Montrose street. 1873
M'Michael, J. M., 8 Victoria terrace. 1881
Macmillan, Daniel, F.E.I.S., 20 Ashton terrace. 1882
M'Neil, John, 70 West Nile street. 1881
[illegible] M'Neill, John, M.A., 14 Derby terrace. 1873
Macnee, Andrew, Scotland street, Tradeston. 1880
[illegible], Donald, M.D., [illegible] College, Cambridge. [illegible]
M'Pherson, George L., 20 Albert road, Crosshill. 1872
Mactear, James, F.C.S., St. Rollox Chemical Works. 1867
[illegible] M'Vail, D. C., M.B., 3 St. James' terrace, Hillhead. 1873
[illegible], John C., Sen., M.D., 10 [illegible] place, [illegible]. 188[illegible]

Main, James, A. R., 25 Hope st. 1870
Manford, Stewart, Tower drive, Gourock. 1874
Mann, John, C.A., 154 St. Vincent street, *Treasurer.* 1856
[illegible] Maxwell, James, 2 Albert road, Pollokshields. 1876
*Marshall, James, Carlston, Kelvinside. 1869
Martin, Thos., 166 Sauchiehall st. 1862
Martin, Thos., 19 Rupert st., Great Western road. 1871
Marwick, J. D., LL.D., F.R.S.E., Killermont House, Maryhill. 1878
[illegible] *Mason, Stephen, 47 Queen street. 1870
Mathieson, John A., 14 Sardinia terrace, Hillhead. 1851
Mathieson, Thomas A., 13 East Campbell street. 1869
Mayer, John, F.C.S., 2 Clarinda terrace, Pollokshields. 1860
Mechan, Arthur, 30 Elliot street. 1876
[illegible] Mechan, Henry, 30 Elliot street. 1879
Menzies, Thos., Hutchesons' Grammar School, Crown street. 1859
Michaelson, M., 5 Woodside place. 1878
Middleton, Robert T., M.P., 179 West George street. 1860
Millar, James, 155 Parliamentary road. 1870
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35 Morrice, Alexander, Tullymet villa, Ayton road, Pollokshields. 1873
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40 Morton, James, M.D., Professor of Materia Medica in Anderson's College, 199 Bath street. 1868
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45 Muir, Thomas, M.A., F.R.S.E., Beechcroft, Bishopton, *Vice-President.* 1874
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50*Muirhead, Andrew Erskine, Cart Forge, Crossmyloof. 1873
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55 Murdoch, James, Glenneuk, Port-Glasgow. 1857
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475 O'Beirne, William, Chemical works, Clydebank. 1881
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480 Paris, Wm., Glasgow Iron Works, St. Rollox. 1869
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485 Patterson, T. L., F.C.S., at John Walker & Co.'s, Greenock. 1873
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490 Pinkerton, R. H., M.A., 46 Bank street, Hillhead. 1880
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495 Pringle, Quintin, B.Sc., B.A., LL.B., 52 St. James' street, Hillhead. 1872
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500 Ramsay, Wm. Craig, 119 St. Vincent street. 1881
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505 Rattray, Rev. Alex., M.A., Parkhead parish, 4 Westercraigs, Dennistoun. 1879
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525 Robertson, Robert A., Nenthorne, Ayton road, Pollokshields. 1877
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540 Salmon, James, F.R.I.B.A., 197 St. Vincent street. 1870
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555 Sim, William, 88 Gt. Clyde street. 1862
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Sloan, Samuel, M.D., 4 Newton terrace. 1877
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560 Smellie, Thos. D., 209 St. Vincent street. 1871
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Smith, Andrew J., I.A., 95 Bath street. 1879
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565 Smith, Harry J., Ph.D., 27 Buckingham terrace. 1877
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570 *Smith, J. Guthrie, 173 St. Vincent street. 1875
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575 Snodgrass, John, Washington Mills. 1880
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580 Stanford, Edward C. C., F.C.S., Glenwood, Dalmuir, Dumbartonshire. 1864
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585 Stephen, Robt. R., Adelphi Biscuit Factory. 1867
*Steven, Hugh, Westmount, Montgomerie drive. 1869
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590 Stevenson, William, Tower Bank, Lenzie. 1870
Stewart, A. D., M.B., L.R.C.S.Ed., 2 Walworth terrace, Kent road. 1876
Stewart, David, 3 Clifton place. 1856
Stewart, David Y., Barrassie bank, near Troon. 1849
Stewart, Henry, City Saw Mills. 1876
595 Stewart, James Reid, 30 Oswald st. 1845
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600 Stuart, J. Watson, 88 St. Vincent street. 1881
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Stoddart, James Edward, Clyde Lead Works, Cornwall street. 1872
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605 Storer, James, 48 French street, Bridgeton. 1875
Strain, John, C.E., 154 W. George street. 1876
Sturrock, David, I.A., 103 West Regent street. 1881
*Sutherland, David, 14 Derby ter. 1880
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610 Swanston, John, 1 Grafton square. 1872
Tatlock, John, F.I.C., 100 Sauchiehall street. 1875
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615 Teacher, Adam, 14 St. Enoch sq. 1868
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Tennant, Charles, M.P., St. Rollox Chemical Works. 1868
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620 Thomson, David, I.A., F.R.I.B.A., 122 Wellington street. 1869
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Thomson, James, F.G.S., 3 Abbotsford place. 1863
625 Thomson, James, Allan & Mann's, 48 St. Enoch square. 1870
Thomson, James, I.A., F.R.I.B.A., 157 St. Vincent street. 1870
Thomson, James, LL.D., F.R.S., C.E., Professor of Engineering in the University of Glasgow, Oakfield house, University avenue, Hillhead. 1874
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Thomson, James R., Clydebank Foundry. 1863
630 Thomson, John, Alliance Foundry. 1876
Thomson, John D., 4 Rosslyn ter., Hillhead. 1870
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Thomson, Sir William, LL.D., D.C.L., F.R.S., Professor of Natural Philosophy, University of Glasgow. 1846
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645 Walker, Malcolm M'N., F.R.A.S., 45 Clyde place. 1853

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650 Watson, Eben., A.M., M.D., 1 Woodside terrace. 1873
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White, John, Scotstoun and Slitmills, Partick. 1875
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665 Wilson, Alex., Hydepark Foundry, 54 Finnieston street. 1874
Wilson, Alex. S., M.A., B.Sc., Professor of Botany, Anderson's College. 1880
Wilson, Charles, 4 Craigpark, Dennistoun. 1875
Wilson, Daniel, 124 Bothwell st. 1872
Wilson, David, Carbeth, by Killearn. 1850
670 Wilson, James, 144 W. Regent st. 1881
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675 Wilson, W. H., 652 Eglinton st. 1881
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680 Wolfe, J. R., M.D., F.R.C.S.E., 18 Brandon place. 1872
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685 Wyper, Jas. C., 131 Renfield st. 1870
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690 Young, James, Jun., Kelly, Wemyss Bay. 1880
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